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PB-260 106

PROCEEDINGS OF NATIONAL CONFERENCE ON SOLID WASTE RESEARCH HELD AT CHICAGO UNIVERSITY ON DECEMBER 2-4, 1963

AMERICAN PUBLIC WORKS ASSOCIATION
CHICAGO, ILLINOIS

PREPARED FOR
PUBLIC HEALTH SERVICE
WASHINGTON, D. C.

DECEMBER 1963

257176

PB 260 106

American Public Works Association

SPECIAL REPORT

PROCEEDINGS

NATIONAL CONFERENCE ON SOLID WASTE RESEARCH

Sponsored By: Environmental Sciences and Engineering Study
Section of the U.S. Public Health Service

In Cooperation With: The American Public Works Association

DECEMBER, 1963

University of Chicago Center for Continuing Education
Chicago, Illinois

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APWA

1313 East 60th Street, Chicago, Illinois 60637

BIBLIOGRAPHIC DATA SHEET

1. Report No.

2.

3. Recipient's Accession No. PB-260 106

4. Title and Subtitle Proceedings of National Conference on Solid Waste Research Held at Chicago University on December 2-4, 1963

5. Report Date Dec 63

6.

7. Author(s)

8. Performing Organization Rept. No. SR-291,APWA-SR-29

9. Performing Organization Name and Address
American Public Works Association, Chicago, Ill.
Research Foundation.

10. Project/Task/Work Unit No.

11. Contract/Grant No. PHS-EF-00549-01

12. Sponsoring Organization Name and Address
Public Health Service, Washington, D. C. Div. of
Environmental Engineering and Food Protection

13. Type of Report & Period Covered Special rept.

14.

15. Supplementary Notes

16. Abstracts

An increasing need for new information and ideas on the collection and disposal of solid wastes resulted in the National Conference on Solid Waste Research: researchers, educators, government officials, equipment manufacturers, and operating personnel brought together to discuss problems and interests in solid wastes. Conference objectives were to stimulate research and young researchers, point out resources for support of research, delineate problems, and project future needs for long-range problems. Conference proceedings present the latest ideas on research in the area of solid waste.

17. Key Words and Document Analysis. 17a. Descriptors

17b. Identifiers/Open-Ended Terms

*Solid wastes
*Solid waste management
Solid waste collection
Agricultural wastes
*Solid waste disposal
Waste transfer stations
Waste processing
Land disposal
Industrial waste treatment
Refuse disposal

17c. COSATI Field/Group 13B

18. Availability Statement

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page UNCLASSIFIED

21. No. of Pages 245

22. Price

FORM NTIS-35 (REV. 10-73) ENDORSED BY ANSI AND UNESCO. THIS FORM MAY BE REPRODUCED USCOMM-DC 8265-P74

ABOUT THE APWA

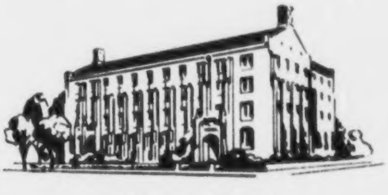
Public works facilities and services are of growing importance to virtually every individual and particularly to those living in urban areas. Many persons are responsible for the development and maintenance of these facilities and services. The purpose of the American Public Works Association is to provide a common meeting-ground for administrators, engineers and other responsible officials whose work pertains to this important field of human endeavor, and to promote the advancement of improved practices which best serve the interests of the general public.

The American Public Works Association was organized in 1937 through the merger of the American Society of Municipal Engineers — founded in 1894 — and the International Association of Public Works Officials — organized in 1919.

It is a non-profit organization which devotes its efforts to the fulfillment of these specific objectives: collect and disseminate information pertaining to public works activities; promote cooperation among all persons and organizations concerned with public works problems; sponsor research projects and committee work so that members may pool their resources and unite their efforts in the study and solution of common problems; stimulate and encourage the advancement of knowledge and the attainment of proficiency in the field of public works engineering and administration; provide opportunities for consultation and the exchange of ideas and experiences; inform members of opportunities for advancement and encourage the adherence by all members to high business and professional standards.

The APWA Research Foundation is an independent, special-purpose organization which was established in 1955 to promote research in the broad field of public works engineering and administration. It functions within the framework of the American Public Works Association, but its operations are governed by a separate Board of Trustees.

The purpose of the Foundation is to serve state and local units of government by continually evaluating by scientific means the status of public works activity, by identifying its major problems, by determining the most promising approaches to their solution and by providing a practical means by which such units of government, with the aid of public-spirited individuals and organizations, may voluntarily contribute to the support of research which will lead to the discovery of ways and means to solve scientifically the public works problems of urban communities.



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Proceedings

NATIONAL CONFERENCE ON SOLID WASTE RESEARCH

Sponsored By: Environmental Sciences and Engineering Study Section of the U.S. Public Health Service

In Cooperation With: The American Public Works Association

This Conference was supported by a U.S. Public Health Service Research Grant No. EF-00549-01 from The Division of Environmental Engineering and Food Protection, U.S. Public Health Service

UNIVERSITY OF CHICAGO CENTER
FOR CONTINUING EDUCATION
CHICAGO, ILLINOIS

DECEMBER, 1963

Foreword

The National Conference on Solid Waste Research grew out of the increasing need for new information and ideas for collecting and disposal of solid wastes. In May, 1962, the American Public Works Association prepared and published Special Report No. 24 titled "Solid Waste Research Needs." This report, prepared under the direction of the APWA Research Foundation for the U.S. Public Health Service, delineated specific research projects in the field of solid wastes storage, collection and disposal. It was recommended that a Conference on Solid Wastes be held to lay the foundation for an on-going research program at colleges and universities.

The Environmental Sciences and Engineering Study Section of the U.S. Public Health Service recognized the need and the value of holding a conference on Solid Waste Research. A planning committee was established to determine the suitability of such a conference. The planning committee recommended that a National Conference on Solid Waste Research be held as quickly as possible.

The major objectives for this conference as set forth by the planning committee were:

To stimulate research on problems in the field

To stimulate young researchers to work in the field

To point out resources for support of research in the field

To delineate the solid waste problems by operational people

To project future needs in order to plan for long-range problems

It was apparent that problems in solid wastes were increasing at a faster rate than they were being solved. Unless immediate action was taken to attract new research personnel to the field of solid wastes, the planning committee felt that a bad situation would deteriorate even further. The only source of research talent, which was not already fully committed to other areas, were the young investigators who had graduated with their Ph.D. within the past five years. Unfortunately, these young researchers were not aware of the research potentials which existed in the area of solid wastes. The planning committee decided to concentrate their efforts on bringing the young researchers together, with a few key research investigators and operational people, in order that the young researchers would be challenged by problems in solid wastes.

To be effective, the planning committee decided to limit the number of conferees to approximately 150. It was felt that too large a group would make communications difficult and participation less stimulating.

The planning committee proceeded to develop the formal program for a National Conference on Solid Waste Research, which was made possible by a research conference grant from the Division of Environmental Engineering and Food Protection of the U.S. Public Health Service. The American Public Works Association, working together with the U.S. Public Health Service, converted the ideas of the planning committee into a working conference.

The National Conference on Solid Waste Research brought together for the first time, researchers, educators, government officials, equipment manufacturers, and operating personnel to discuss their problems and interest in solid wastes. This 2-1/2 day meeting provided an opportunity for each group to communicate their views to the other groups. As a result, new approaches were suggested and new concepts arose to take the place of old views.

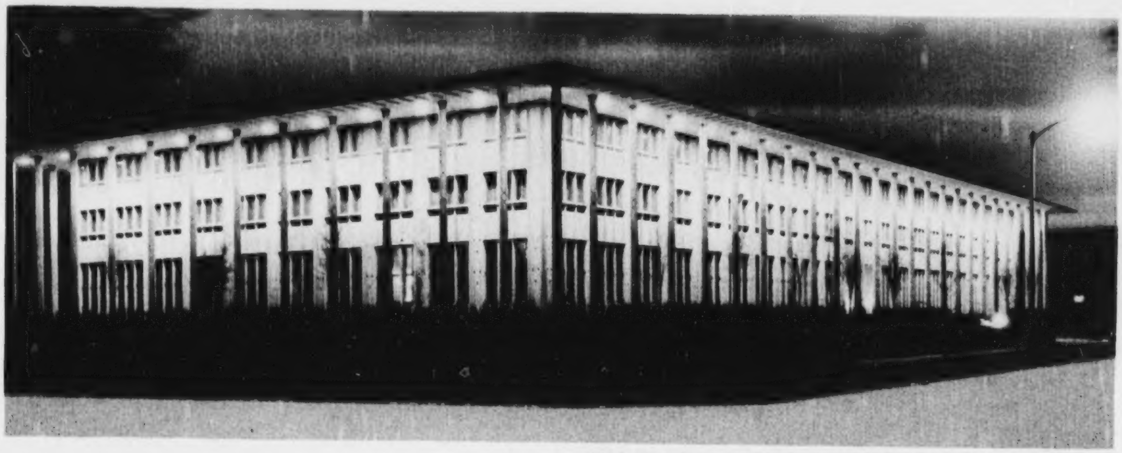
The proceedings, as presented in this volume, represent the latest ideas on the research needs in this area, as seen by the Conference participants. Unfortunately, it is not possible to present each and every word spoken at the Conference, or to present the spirit and the excitement which was generated. An effort has been made to present the significant discussions from the floor as well as the complete texts for each speaker. It is hoped that the remarks of the participants have not suffered unduly in editing. As is often the case, an omission occurs inadvertently. Unfortunately, the paper by Representative John Lesinski of the 16th Michigan District is omitted from this volume. Congressman Lesinski was unable to prepare a formal paper, as a result of an extremely busy schedule. The talk entitled "The Solid Waste Problem as a Congressman Sees It" was extremely informative to all those who heard it.

In looking back on the Conference, there is no doubt that it was a success. Whether or not the Conference stimulates significant research remains to be seen. Only time will answer this question. These proceedings will serve to stimulate new ideas in solid waste research for those who could not attend this Conference and will serve as a reminder of the potentialities ahead for those who attended the Conference.

This Conference was a success because of the contributions of the people who participated in it. Many people gave their time, their knowledge and their ideas, so that others could benefit. It is not possible to name everyone who contributed to the success of the Conference, but it is possible to extend our appreciation to each person who helped with the Conference. Our field has grown in stature because of your efforts.

Ross E. McKinney, Chairman
Program Planning Committee

At the Conference



University of Chicago Center for Continuing Education, Chicago, Illinois. Site of the National Conference on Solid Waste Research.

Papers presented at the concurrent panel sessions and subsequent discussions highlighted many needed areas for research.

Summary reports by the Group Chairman climaxed the two and one half day conference.

THE CITY OF NEW YORK
OFFICE OF
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PAUL R. SCREVANE
PRESIDENT

The American Public Works Association is pleased to have had the opportunity to cooperate with the U.S. Public Health Service in sponsoring the National Conference on Solid Waste Research at the University of Chicago, December 2-4, 1963. I sincerely hope that the proceedings of this Conference will help to demonstrate the need for further research in this particular field and encourage students as well as faculty members at our colleges and universities to give greater attention to refuse collection and disposal problems.

For many years the American Public Works Association has conducted a program of activities designed to assist public officials in their efforts to develop efficient methods of collecting and disposing of solid wastes. It has, for example, issued an authoritative text on "Refuse Collection Practice" and another on "Municipal Refuse Disposal". Unfortunately, it is not in a position to undertake the diversified kind of research program needed in this field.

It is for this reason that the membership of this Association has adopted resolutions requesting the Federal Government, through the United States Department of Health, Education, and Welfare, to provide for a more adequate program of basic and applied research in the field of solid waste collection and disposal.

The need for expanded activity in this field has also been recognized by other important organizations such as the American Municipal Association which included the following statement in its National Municipal Policy for 1963 -

> "A continuing program or research is of vital importance in all branches of public works. The proper storage, collection and disposal of community solid wastes (garbage and rubbish) is basic to a clean and healthful environment and involves the expenditure (by municipalities) of approximately $1.5 billions per year. The problems associated with solid waste disposal are becoming increasingly difficult and expensive to solve because of the adoption of more rigid air, land and water pollution control requirements and the expansion of population, and growing metropolitan complexes will intensify such problems. The Federal Government has, for many years, provided funds to support research in many fields of activity, including those involving the handling of liquid and gaseous wastes. Therefore, the American Municipal Association urges the Congress to enact legislation and appropriate sufficient funds to support a broad program of basic and applied research on the storage, collection and disposal of community solid wastes and recommends that this program be administered by the Department of Health, Education, and Welfare."

We sincerely hope that the readers of this publication will take positive steps to support a more active research program in this field or become directly involved in the kind of research herein proposed.

Sincerely yours,

Paul R. Screvane

Paul R. Screvane, President
American Public Works Association

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OFFICE OF THE MAYOR

NATIONAL CONFERENCE ON SOLID WASTE RESEARCH

University of Chicago Center for Continuing Education

December 3, 1964

Gentlemen:

First, let me extend to you a very cordial welcome to the City of Chicago. We are delighted that you chose our city in which to hold this Conference.

I would also like to commend the U. S. Public Health Service and the American Public Works Association for sponsoring a meeting of this kind. The proper storage, collection and disposal of garbage, rubbish and other types of solid wastes is a serious problem confronting virtually every city and metropolitan area in the United States.

We in the City of Chicago have taken positive steps to deal with this problem under the able leadership of Commissioner Lloyd M. Johnson and his Deputy, Theodore C. Eppig. The three new incinerators built in recent years incorporate the most advanced design concepts and are the key elements of our waste disposal program.

Even though our City has made significant progress in modernizing its refuse collection and disposal operations, we recognize that much more must be done. We realize that many communities in the Chicago Metropolitan area are faced with serious problems since the large tracts of land needed for the sanitary landfill method of disposal are rapidly disappearing. Many of our neighboring communities cannot afford to build incinerators to handle the wastes generated in their own limited areas and the cost of hauling refuse to distant disposal sites is quite expensive.

Since the improper disposal of solid wastes can create polluted conditions in the air, water and land surrounding the City of Chicago, we have a strong interest and desire to see adequate measures taken to provide a clean and healthful environment in the entire metropolitan area.

As you know, the public demands immediate value from its tax dollars. This is perhaps one of the primary reasons that local communities have been reluctant to invest in needed research programs to create a more healthful environment in our communities. I am proud of the fact that our Department of Streets and Sanitation has contributed to the support of several important research projects sponsored by the APWA Research Foundation. It is important that state and local units of government give their full share of support to such programs.

It is also important for the Federal Government to meet its responsibility in supporting research programs in the field of municipal solid waste collection and disposal. Excellent research programs have been established to control the disposal of liquid and gaseous wastes and thereby effect a more healthful environment for the people. I sincerely hope that the Department of Health, Education, and Welfare and the Congress of the United States will direct their attention to the solid waste disposal problems facing cities and villages and support the development of an expanded research program in the waste disposal field since such efforts are certain to result in a more healthful environment for the people of this Nation.

Richard J. Daley
MAYOR OF CHICAGO

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Proceedings

Dimensions of the Solid Waste Problem

J. E. McKee
Professor of Environmental Health Engineering
California Institute of Technology
Pasadena, California

A keynote speaker has a difficult assignment. He is expected to set the stage for the conference and to inspire all of the subsequent speakers, as well as the audience. But at the same time he must be careful not to say anything. Certainly he cannot encroach very far on the material that surely will be covered by speakers assigned to specific topics. He should avoid detailed data. He must be cautious not to draw conclusions or make recommendations, inasmuch as those privileges are reserved for the participants who will make the closing statements. He can ask questions, but in so doing he must not display his gross ignorance of the subject. In short, he must operate within very narrow but ill-defined boundaries. Consequently the audience, the reader, and subsequent speakers should be tolerant if this keynote address violates many of these requirements.

The waste products from man's multifarious activities on this planet may be classified as atmospheric, liquid, and solid. Each type, in turn, may be further categorized by source as municipal, industrial, or agricultural. This conference is concerned with solid wastes from all three sources, supposedly to the exclusion of liquid and gaseous wastes. Yet, we cannot divorce our thinking from air and water pollution, for often the method of handling one form of waste creates problems in the other forms. The backyard burning of refuse, for example, creates serious air pollution. A sanitary landfill, as another example, may possibly cause degradation of ground-water quality. Furthermore, the household grinding of garbage turns a solid-waste problem into a liquid one. Although this conference is oriented primarily toward solid wastes, let us remember that the problem must be considered in its broad context.

It is conventional to divide the solid-waste problem into two major areas: (1) collection, including storage, transfer, and transport, and (2) disposal, including any concomitant treatment. Indeed, the recent textbooks on solid waste by the American Public Works Association are entitled "Refuse Collection Practice" and "Municipal Refuse Disposal". The preliminary program for this conference divided each of these two areas into two subjects. Consideration of the quantities and characteristics of solid wastes has been separated from the general area of collection, while the possibilities of conservation and salvage will be discussed independently of the disposal concepts. These divisions are logical and the program planners are to be commended for their prudence.

The handling, disposal, or salvage of solid wastes from industry and agriculture have always been recognized as provinces of private enterprise. Few of us, if any, will quarrel with this precept. In contrast, however, it is generally considered that the collection and disposal of domestic solid wastes are responsibilities of municipal government. Yet many cities, especially the smaller ones, make no provision for collection of refuse, and the householder is expected to transport his solid wastes to an open dump designated by the county or operated privately. In other communities, including my own unincorporated area, no public provision is made for refuse collection, but almost every resident contracts for private service.

An extreme case occurs in many Alaskan communities near the Arctic Circle where each householder tosses his trash in the yard or nearby vacant lot, knowing that it will soon be frozen and covered with snow. Comes spring and the thaws reveal the most unsightly mess that you could ever imagine. Another extreme case occurs at a picturesque northern California seaside village where the town fathers provided a chute from a bluff into the ocean. Householders from miles around dump their trash on the chute and watch it cascade into the sea waters. Gulls hover around and quickly gulp the bits of garbage. When the winds are on-shore and strong, which is frequently, the chute acts as a draft tube. Unless it is heavily weighted, a bag of trash will be caught in the updraft and tossed skyward.

These situations are mentioned to illustrate two concepts that are proper subjects for consideration at this conference, but are likely to be overlooked by sophisticated research personnel. First, it is essential to establish the proper responsibility for the collection and disposal of domestic solid wastes. Research into public administration on this subject may be indicated. Furthermore, the methodology of collection, disposal, salvage, etc. will depend to a large extent on whether the responsibility lies with government or with the individual householder teamed up with private enterprise. Second, it is important to recognize that many of the problems of solid waste are associated with small communities, often unincorporated. Research on the solid-waste problems of large metropolitan areas may have little or no applicability to towns of 10,000 population or less. Let us not overlook this phase of the problem.

Solid Wastes in Perspective

It is interesting to compare the weight of refuse from a community with the weight of its liquid and gaseous wastes. In Los Angeles County, for example, the dry weight of suspended solids in the liquid wastewaters has been found to average 105 grams (0.23 lb.) per capita per day. Even if allowance is made for the increase of dissolved solids over those in water supply, the total dry weight of solids removed from the community via the liquid route is no more than 200 grams (0.44 lb.) per capita per day.

Solid wastes, collected from households in the form of garbage, combustible material, and non-combustibles, average about 1400 grams (3.2 lb.) per capita per day as collected, or about 760 grams (1.7 lb.) per capita per day on a dry-weight basis. Another 125 grams (0.28 lb.) per capita per day (dry weight) are removed from commercial establishments, making the total removal of solid wastes equal to 865 grams (1.91 lb.) per capita per day or more than four times the removal of solids by the liquid route.

Perhaps this is not the time or place to mention the total weight of solids that go to the atmosphere, but why not face the facts? Gaseous wastes are conventionally measured by weight as hydrocarbons, oxides of nitrogen and sulfur, carbon monoxide, organic gases, and aerosols. The major products of combustion, carbon dioxide and water, are not considered as gaseous wastes because they are not normally deleterious. For the air pollutants measured in Los Angeles County in 1962, the total weight averaged 9580 metric tons per day, of which 84 percent came from vehicles and 16 percent from stationary sources. This amounts to about 1470 grams (3.2 lb.) per capita per day on a dry-weight basis, or 70 percent more than the dry weight of solid wastes. Indeed, the engineering and enforcement functions of the Los Angeles County Air Pollution District were instrumental in preventing an additional 4100 metric tons per day of gaseous pollutants from stationary sources. Had these wastes entered the atmosphere, the total weight of gaseous wastes would have been double the weight of solid wastes.

It is apparent, therefore, that the atmosphere is the major avenue for disposal of the waste products of modern cities. But the atmosphere in many of our cities is already overburdened with wastes. To convert solid wastes to gaseous wastes by incineration will only aggravate this problem.

We have seen that the dry weight of solid wastes in Los Angeles County is over four times the dry weight of solids removed by the wastewater system. How do the annual costs of collection and disposal compare? It is difficult to assemble precise figures but the following estimates are approximately correct and serve to illustrate the point.

For the combined populations served by the City of Los Angeles and the County Sanitation Districts, the following per capita costs have been estimated.

Approximate Cost Per Capita Per Year
Collection and Disposal

	Wastewater	Refuse
Operating costs	$1.45	$4.80
Amortization of capital costs	3.50	0.85
Totals	$4.95	$5.65

By way of a rough comparison, the curbside collection fo all of my household refuse twice weekly by a private operator costs $2.50 per month, or $30 per year, or $6 per capita per year for our family of five; so we are pretty close to the average, with an allowance for profit by private enterprise.

For refuse, it is estimated that 80 to 90 percent of the total cost is attributable to collection and transportation, with only 10 to 20 percent arising from disposal by landfill operations. If incineration is employed, approximately 60 percent of the total cost arises from collection and 40 percent from incineration.

From the foregoing table it is apparent that the total cost of wastewater disposal is almost as high as that for refuse disposal, despite the fact that the latter system removes over four times as much dry weight of solids. The major contrast in the two systems arises in the comparison of operating costs and amortization. The big cost for wastewater comes from the high capital investment, which is estimated at over $615 million counting treatment plants, trunk sewers, and all street laterals. In the foregoing table, this cost has been amortized at 3 percent interest for an average life of 60 years and a present served population of 5.6 million. It should decrease on a per capita basis in future years because the systems are close to their ultimate development. The capital cost factor for refuse disposal is relatively low, consisting primarily of the short-time amortization of the cost of collection vehicles. This annual cost is likely to increase in future years.

The truly significant comparison is in operating costs, where the figure for refuse is over three times that for wastewater. These costs, which are based largely on expenditures for labor, are bound to increase markedly in future years. It may be expected, therefore, that the next decade or two will see a significant spread in the total cost of handling wastewater and refuse, unless research develops methods for lowering the operating costs of refuse collection.

To recapitulate: in Los Angeles County, the solid-waste problem is over four times as large as the liquid-waste problem on a dry-weight basis, slightly larger in total annual cost, and over three times as large on the basis of annual operating costs. It is expected that comparative figures for other metropolitan areas will be of a similar magnitude. But what are we doing to solve the problems of solid wastes? How much brainpower is being devoted to solid wastes vis-a-vis liquid wastes? Why hasn't more attention been paid to solid-waste problems in the past?

The Application of Brainpower

It is difficult to select cirteria for evaluating the brainpower that is applied to a given system or area of endeavor. The following yardsticks, however, come to mind:

1. Research expenditures, as a percentage of the gross product cost or revenue.
2. The number and eminence of engineers and scientists associated in any way with the endeavor.
3. The relative expenditures for engineering management and control of the system.
4. The gross fees paid to consulting engineers for designing or investigating specific systems.
5. The number of professors and students interested in this area of endeavor.
6. The number and quality of scientific or engineering papers being published in reputable journals.

By any of these parameters, solid wastes compare miserably with liquid or gaseous wastes. Total expenditures for research in the area of liquid wastes are in the general magnitude of $10 million per year, including sponsorship by federal, state, and local agencies, industrial associations, private industries, and philanthropic foundations as well as unsponsored university and industrial research. In contrast, the total research expenditures for refuse collection and disposal probably do not exceed $200,000 per year including private funds as well as about $70,000 per year from the USPHS. Hence, the funds spent annually for research on liquid wastes are at least 50 times those spent on solid wastes. This lack of research is reflected in the sparse number of scientific papers on solid-waste problems.

In many industries and advancing technologies, it is not uncommon for 5 percent or more of the total revenues to be plowed back into research to improve the product or to cut costs of production. The gross expenditures for refuse collection and disposal in the USA have been estimated in the general order of $1 to 2 billion per year. At 5 percent, the research expenditures might well amount to $100 million per year or more, or 500 times the current rate. Such research should pay handsome dividends in reduced costs and better service.

The number of eminent engineers and scientists associated in any way with solid-waste problems is pitifully small in relation to those engaged in wastewater disposal. To be sure, there are several competent engineers in the larger cities who devote a great deal of their time to solid wastes but they are far outnumbered and outglamored by their colleagues in the wastewater field. This contention could be verified by totalling the salaries of engineering and scientific personnel working on the two problems in any large metropolitan area.

Consulting engineers are seldom engaged for investigations or design related to solid wastes and indeed they do not tend to seek such work. To be sure, the design of a large municipal incinerator calls for superior engineering competence and some engineering firms have specialized in such work. By and large, however, the gross fees paid to consulting engineers in the solid-waste field are negligible compared with those in the water supply or wastewater areas. Finally, few professors of engineering have taken any interest in solid wastes compared with the scores of competent ones in the wastewater field.

The foregoing parameters indicate that very little brainpower is being applied to the problems of solid wastes, but why has this field been so neglected? There are several apparent reasons. First, there has been no strong pressure or demand for scientific evaluation on research, either from municipal administrations, the regulatory agencies, or the public at large. Too many people are willing to let sleeping dogs lie. Second, there have been no epidemics attributable to improper handling or disposal of solid wastes. While there is ample reason to believe that the insanitary handling of solid wastes contributes to endemic disease, there have been no Donoras or Broad Street wells to dramatize the problem. Third, federal and state agencies have not provided the direction that this problem deserves. Most of the impetus to date for scientific studies and research has arisen within the American Public Works Association, or the Sanitary Engineering Division of ASCE. Fourth, it is difficult to reduce the problems of solid wastes to clear-cut scientific or engineering investigations because the economic and political factors are so overpowering.

All of these reasons combine to produce a general lethargy of research in solid waste problems. It is one of the duties of this conference to overcome this lethargy and to stimulate research.

Public Health Aspects

Reference has been made already to the lack of public-health implications in refuse handling and disposal. Let us examine this facet of the problem in more detail. You will hear still more about it from the luncheon speaker.

Flies are known vectors of general filth, typhoid and para-typhoid bacteria, other enteric pathogens, and presumably viruses such as those causing hepatitis. Flies breed in garbage and other organic refuse both at the point of origin, in transit, and in some forms of final disposal. They are difficult if not impossible to control by insecticides. The only effective remedy lies in twice-weekly collection, close attention to general sanitation at the household and in the collection system, and fast efficient disposal either by sanitary land fill or incineration.

Rodents are also ubiquitous near refuse, whether at the household, in transportation, or at the point of disposal. They too can best be controlled by rigid sanitary measures and rapid handling of refuse.

A former public-health hazard of garbage handling appears to be waning in importance. Thanks to the advent of vesicular exanthema, a disease fatal to swine, the feeding of raw garbage to hogs has been largely discontinued. With the control of vesicular exanthema has come a concomitant decrease of trichinosis, a disease debilitating to man but apparently not serious enough to influence the industry. In Enterprise, Alabama, there is a monument to the cotton-boll weevil, which wiped out the cotton crops and forced the destitute farmers to turn to the cultivation of peanuts, from which they became wealthy. It is time now for us to erect a monument to vesicular exanthema, which has almost eliminated a human disease that man himself seemed to be powerless to control.

Air pollution is a definite hazard to health and it may be a by-product of certain practices in the collection and disposal of solid wastes. In the absence of adequate collection and enforced rules against burning, much of the trash of a community may be converted into gaseous pollutants by inefficient combustion. Where central municipal or industrial incineration is employed, the increment to atmospheric pollution may still be significant. Corollary to the backyard incineration of refuse is another hazard to health, namely uncontrolled fire. This hazard also arises from the improper storage of refuse.

Water pollution may also be an adjunct of solid waste storage and disposal. Leachings from the accumulation of solid agricultural products have been known to pollute surface streams. Sanitary landfills, furthermore may pollute nearby ground waters either by direct leachings or even by the diffusion of gases of decomposition through the soil. These problems are being investigated at present in California.

None of the foregoing problems of public health are acute or dramatic; but they are definitely real. None are likely to produce an epidemic or gross contamination of water or air; but they may contribute markedly to endemic disease and they certainly lead to a general degradation of the environment.

Economic Aspects

It is in the fields of economics and public relations that the real pressure for better handling of solid wastes is likely to come. For Los Angeles County, the annual per capita cost of household refuse collection and disposal was estimated to be $5.65. If this figure is applied to the entire population of the USA it is evident that the gross expenditure for domestic refuse handling exceeds one billion dollars per year. The addition of industrial, commercial, and agricultural solid wastes will double or triple this expenditure. But these are only the apparent or well-established costs. There are dozens of other costs or economic losses resulting from improper solid-waste handling that are indirect or hidden. They include items such as depreciated property values, air and water degradation, fire and rodent damage, and medical bills.

As pointed out earlier in this paper, the collection of solid wastes by primitive hand labor and small vehicles accounts for over 80 percent of the total cost, especially where sanitary landfill is practiced for ultimate disposal. If any significant economies are going to be made, they will have to relate to the collection and transportation functions. During this conference you will undoubtedly hear about the feasibility of grinding trash and discharging it to the sanitary sewer system. Other ideas, no matter how radical, will be welcome.

Industrial engineers have applied operational analysis and systems engineering effectively to problems of production, storage, transportation, and disposal of commercial products. Many of these same procedures can be applied to the collection of refuse. Fortunately, one of the sessions at this conference will be devoted to this subject.

Sanitary landfill has been shown to be an effective and economic method of refuse disposal in most areas. But land suitable for landfill is fast disappearing in many metropolitan areas. Research is needed to discover ways for putting more solid wastes in the available landfills. There are possibilities that refuse can be compressed into dense packages, sprayed with plastic or bituminous material to prevent moisture from entering or leaving the package, and arranged compactly in landfills. Such units might even be dumped at sea without repercussions.

It is difficult at this time to consider that composting and agricultural utilization of the compost will soon become an economic system of solid-waste disposal. There is no sizable market for compost from solid wastes and none is likely to develop in the near future. Los Angeles County, for example, has a tremendous surplus of organic soil conditioner, owing to the fact that its resident bovine population is much greater than that of any other county. Los Angeles County is truly the nation's No. 1 "cow county". As a result, manure is sold very cheaply. Digested sewage sludge cannot compete with the deluge of bovine manure, so obviously composting is out of the question at this time. In other sections of the country, chemical fertilizers make composting uneconomic. We should not, however, ignore the potentialities of composting. The time may well come in a few decades when the USA is no longer an area of crop surpluses and when many of the conservation measures used now in Europe will be required here. For this reason, it is prudent to continue research on composting. This subject, no doubt, will be debated thoroughly in Panel Session D.

Public Relations Aspects

The pressure for more action and more research in solid-waste handling may well arise from the general public before it develops from public-health officials, economists, engineers, or conservationists. The American public has demonstrated that it is willing to pay for convenience and gadgetry, as witnessed by the home garbage grinder. It is not difficult to prove that the combined disposal of garbage with other trash is more economic than the amortization and operation of a garbage grinder, but what housewife is interested in economics? Similarly, engineering studies may possibly prove that the segregation and separate collection of garbage, tin cans, and other trash, with salvage of the cans and hog feeding of the garbage, will be more economic than twice weekly collection of all refuse in one container; but the householder much prefers the convenience of combined collection and detests the nuisance of segregating solid wastes. The public is definitely willing to pay more for service that is demonstrably better.

Property owners are rightfully apprehensive about, or indignant over, unsightly collection trucks and crews, curbside pick-up, noisy collection (especially at night or early morning), or the nearby location of incinerators, sanitary landfills, or transfer stations. The public would like to sweep the solid-waste problem under the rug or put it behind a door; but recognizing that these alternatives are not available, the public wants convenience and cleanliness. It is willing to pay more if the results are clearly superior. Smart politicians recognize this tendency and try to capitalize on it. As engineers and scientists in environmental health, we too should aim toward optimum convenience to the public, even if the costs are somewhat greater than minimum.

Research Needs

From its very title, this conference is oriented toward research. Presumably it will develop a long list of problems that require investigation and it will recommend procedures to stimulate research and development in the solid-waste field. As many of you know, an excellent report on "Solid Wastes Research Needs" was prepared by the American Public Works Association in May 1962. It contains brief descriptions of 33 potential research projects. Four additional solid-waste problems are included in "100 Problems in Environmental Health", distributed by the USPHS in 1961. Several research projects in solid wastes are being sponsored currently by the USPHS and by the California Water Quality Control Board.

In compiling a list of potential research problems, this conference should ask, "who is able and willing to undertake such research"? Are trained personnel available for these projects? Will they be willing to forego research in other phases of environmental health to tackle the more mundane problems related to solid wastes? What incentives can be provided to entice competent research personnel into this field of endeavor?

Research is frequently the hand-maiden of post-baccalaureate education. If research is to be conducted at universities, should it be accompanied by graduate courses or programs oriented strongly toward the solid-waste problem? Can such courses or programs be made sufficiently sophisticated to meet the academic requirements of our better engineering schools? These are questions that the conference might well debate.

Summary

This keynote address has attempted to establish the need for the conference and to set the stage for some of the discussions. It was written without any knowledge of what subsequent speakers will say. Undoubtedly many parts of it will be irrelevant in the light of how this conference develops. For that reason, a keynote speaker should have the privilege of rewriting his address after the conference is completed.

The conference chairman and his planning committee are to be commanded for developing an excellent program and format for this conference. Many thanks are due to the American Public Works Association and the University of Chicago for playing host and providing excellent facilities. Finally, I thank all of you for attending at this busy season of the year and I wish you the best of success in your deliberations.

Public Health Aspects of the Solid Waste Problem

Robert J. Anderson, M.D.

Assistant Surgeon General and Chief, Bureau of State Services,
U.S. Public Health Service, Washington, D.C.

It has been said a number of times in recent years by competent experts that this country is at least ten years behind in coming to grips with the problem of environmental health. These men -- scientists and public administrators -- point to the explosive expansion of our chemical industry, the surging trend toward living in cities or metropolitan areas, and the continued growth of our whole industrial complex, with its accompanying effect on the general environment.

These three movements, it is explained, have aggravated in increasing measure, our problems of water pollution, air pollution, radiation hazards, the need for additional work in occupational health safe guards, restaurant sanitation and general milk and food purity activities, and research into the dangers of the use of pesticides, among others.

Although I am certainly in agreement with the general assertion of our ten year lag, I think is fair to say that in some few of these fields of activity -- such as water pollution control -- our greatly increased efforts in recent years may have put us less than ten years behind. In other fields, however, we are considerably more than ten years behind -- and in this category I would certainly put the general problem of solid waste collection and disposal.

When one surveys the complexities of the solid waste problem it may seem to some a little hard to classify it as an environmental health problem. The discussion proceeds almost immediately to the difficult questions of economics, engineering and city planning aspects, and other non-health angles.

It is necessary to remind ourselves, I believe, that the solid waste problem is fundamentally a health problem. Just as we who are concerned with this problem are conscious of the fact that no really new or radically different ideas have emerged in waste disposal operations for half a century so we must also remember that 42 years ago one of the pioneers in the field laid down three basic requirements for waste disposal; the first was "the absence of danger to public health." And it still holds true today. In other words, the barriers and difficulties we face here are economic and engineering and jurisdictional in nature, but the reason we are concerned is the protection of the public health.

Let us examine for a moment the nature of the various health factors that create our concern. The most prevalent disposal system of serious danger to health is, of course, the open dump, with its flies and rats. Typhoid fever, cholera, summer diarrhea, dysentery, tuberculosis, anthrax, opthalmia, as well as intestional worms, can be transmitted by flies. The importance of adequate refuse handling in controlling those communicable diseases was long ago recognized.

The control of fly breeding by provision for adequate garbage collection; the elimination of garbage dumps; the provision for proper disposal of feces; are the first rules for the control of typhoid fever.

In addition, plague, murine typhus fever, leptospirosis, ratbite fever, trichinosis, food poisoning, richettsialpox, lymphocytic choriomeningitis, and rabies can be transmitted by rats and mice; while malaria, yellow fever, dengue, mosquito-borne encephalitis, and filariasis can be transmitted by mosquitoes.

Poor refuse handling commonly provides food for flies, cochroaches, and domestic rodents. Open cans and bottles catch and hold water in which mosquitoes can breed, so that many individual citizens unknowingly but actively encourage the proliferation of these disease-carrying pests.

Many experts in this field have pointed out that garbage is usually the chief source of food for rats in urban areas. Food handling establishments and grocery stores are particularly attractive to rats, but many rat infestations are supported entirely on improperly stored garbage. Limitations on food, water, or harborage are the only determinants to the size of a community's rat population.

The ability of flies to quickly find and oviposit on any suitable material, including garbage, is well known. The infestation of garbage in containers was studied in detail at Phoenix, Arizona, and it was found that Phaenicia pallescens adults displayed the ability to enter garbage containers through openings as small as one-eighth of an inch in diameter. Other studies found that as many as 70,000 flies were produced per cubic foot of garbage exposed to ovipositing flies.

When flies infest garbage, the larvae are usually concealed in the garbage or in the lower part of the can so that the householder ordinarily is unaware of their presence. Although many of these larvae are carted away when the refuse is collected, studies have shown that during warm weather large numbers of larvae migrate from the cans before the refuse is collected. Campbell and Black, for example, found that an average of 1,128 fly larvae per can per week migrated from 30 refuse cans to pupate before the combined refuse was collected at Concord, Calif. During the 2 years of study, a maximum count of 23,208 larvae was obtained from one can in a single week. Of interest was the fact that low counts were obtained consistently from only two cans, apparently because one householder used a garbage grinder and the other always wrapped the garbage in newspapers.

The fly-infested refuse that is ordinarily collected during warm weather must be carefully handled to prevent fly production. In order to prevent fly emergence by compacting the cover material at sanitary landfills, a California study showed that there were four essential factors to consider: soil that can be compacted, suitable equipment for compacting the soil, adequate range of soil moisture, and adequate thickness of cover.

Although no reasonable amount of uncompacted cover would prevent emergence, since house flies have emerged through 5 feet of uncompacted cover, only a 6-inch layer of compacted cover was sufficient to prevent fly emergence.

In addition to disease transmitted by vectors, air pollution is becoming a more serious problem. Open dumps, where burning is used to reduce the volume of solid wastes, almost always produce large quantities of smoke and odors. Improperly designed and operated municipal incinerators also contributed significant quantities of objectionable air contaminants. Added to these sources are backyard trash burners, on-site incinerators, and on-site open burning of bulky refuse that contribute additional air contaminants in most communities.

One scientist noted recently that, according to data collected in state-wide air pollution surveys, "burning dumps cause air pollution problems in about 25 percent of the urban communities of the country . . . They are the most frequently reported cause for localized air pollution problems."

Another study investigated the source and nature of air contaminants which produce asthma in New Orleans. A statistically significant relationship was found between the daily asthma admissions at Charity Hospital emergency clinic and the prevalence of one air pollutant, a poor combustion particle associated with silica. All possible sources of this material were not examined; however, air samples taken at a dump in the summer of 1961 revealed large quantities of this particle.

Water Pollution is also becoming a serious factor in this picture. Wherever refuse is deposited on land, the impact on surface waters or subterranean aquifers may be significant.

The available information concerning the effects of refuse fills on the quality of the adjacent ground water has been organized and reviewed by a research contractor for the California State Water Pollution Control Board. It is interesting to note, by the way, that this study was done because the drinking water supply of a major city was becoming objectionable.

This study showed that there are three basic mechanisms by which refuse fills can pollute the ground water. They are:

1. Direct horizontal leaching of the refuse by ground water,
2. Vertical leaching by percolating water, and
3. The transfer of gases produced during refuse decomposition by diffusion and convection.

Further investigations were recommended on gas production and movement, leaching rates, percolation, and methods of controlling the movement of gas and water in landfills.

In an earlier study by the California State Water Pollution Control Board it was concluded that the movement of water through incinerator ash dumps will leach soluble salts and alkalies from the dump. An investigation at a sanitary landfill proved that ground water in the immediate vicinity will become grossly polluted by continuous or intermittent contact with deposited refuse.

Bacterial and organic contamination may be very limited in range, but chemical pollution, i. e., mineral salts, may travel some distance before the effects of dilution are evident. Although the passage of landfill leachate through sand or gravel may be expected to improve conditions so far as bacterial and organic pollution is concerned, chemical pollution can be expected to reach the ground water along with percolating water. Therefore, proper location and operating practices that prevent supersaturation of a fill are essential, thus compounding the problem of the engineer out searching for new ground for landfill operations.

From an occupational health and accident prevention standpoint, solid waste handling presents additional formidable problems. A study of the Department of Sanitation of New York City, found that arthritis, cardiovascular diseases, muscle and tendon diseases (particularly muscle ailments affecting the back), skin diseases, and hernia could all be classified as occupational diseases of refuse collectors. Sanitation workers were also found to have an extremely high injury frequency rate, exceeding that of all other occupations previously studied, with the exception of logging. The study report also observed that "the rate was more than twice as high as that for firemen and policemen, and surpasses even that of stevedores."

These statistics are even more startling when the methods used for selection of these men are considered. New York City sanitation men candidates must first pass a qualifying written examination, then a physical examination, and finally a series of tests to determine physical fitness. The physical fitness tests were complied by the Head of the Physical Eudcation Department of New York University, to determine endurance, agility, strength, and coordination. The tests consisted of a qualifying lift of a 120-pound weighted can to a 4-1/2 foot shelf; followed by (1) an 80-pound dumb-bell military press with each hand; (2) a 60-pound abdominal lift; (3) an agility test -- broad jump, hurdle, fence trap, and eight-foot wall to scale; (4) a 120-yard run against time with a 50-pound dumb-bell in each hand; plus (5) a coordination test in which the candidate operated a specially constructed mock-up of a sanitation truck.

Some indication of the rigorous selection made with such a testing procedure was given in the following records of a 1939 test: 85,000 men filed for the job; the final list contained the names of the top 7,800 candidates of the 22,000 men who survived all phases of the examination.

Many fires and home accidents are caused by poor refuse handling practices. Discarded items that are not properly stored for collection are also particularly attractive to children. Unsanitary and unsafe conditions in yards and family refuse storage areas have resulted in literally thousands of minor and severe accidents. In one case, a 13-year old boy and his friend were playing in the alley behind his house. In the trash, they found some old milk bottles with "some fluid" in them. One of the boys struck a match and threw it into one of the bottles. The resulting explosion caused third-degree facial burns and required long-term hospitalization.

While the accident aspect of our problem is in a sense a minor one, it is illustrative of the manner in which the whole problem is growing. Our data has shown that the increasing uses of pesticide products in the home and various new miracle drugs -- so-called because of their potency -- has resulted in correspondingly greater amounts of these things in the solid waste load and more accidents such as I have just mentioned.

I hope that these varied examples have demonstrated, that we believe this problem to be an integral concern of the whole environmental health picture. We have, in fact, in the Public Health Service taken steps recently to make the solid waste activities a separate and distinct area of Federal activity in the budget to the Congress, organizationally, and also in the area of research grants.

We all know that many people are already at work on this problem. Manufacturers who have been making incinerators for decades are trying to improve the efficiency of their machines. Others are working on composting and similar methods. We wish them all good luck. But we also believe that a vast reservoir of experience and knowledge exists in our city and county government officials and professionals. We believe that if this conference here in Chicago can bring that knowledge and skill together with young researchers for a joint effort we can lay the ground work for real results.

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Ecological Considerations, Administration of Solid Waste Collection and Disposal Systems and Research Implications

Frank M. Stead, Chief
Division of Environmental Sanitation
California State Department of Public Health
Berkeley, California

I came to this conference with a prepared paper but as the various talks unfolded, one by one the sheets of this paper disappeared until finally the whole mass disintegrated into a glob of solid waste.

Perhaps it is just as well because one must begin with the present in any discussion, and I would like to start from where we are now and carry you forward into the future so as to give you a glimpse of what it will be like to manage the environment in these United States a scant twenty years hence.

A little over a year ago, a relatively small group of us in California undertook to engage in this type of speculation, and what started out as an intriguing mental exercise turned out to be a most sobering, stimulating and deeply moving experience.

What will happen in California will happen in the rest of the country. If there is any distinction, I think it may be that we face some of the environmental problems earlier than the rest of the country. But the path we tread, you will follow.

The first inescapable conclusion was that if we consider the current, tremendously rapid rate of change, we suddenly realize that the present concepts upon which environmental sanitation programs have been based for two hundred years, will be completely obsolete and unworkable as principles to guide our actions.

Environmental sanitation programs in the United States are based on three assumptions. The first is that unwanted waste products are best handled by discharge into the environment--this vast, unlimited resource that can handle our problems for us without very much help.

The second assumption is that having done this, we can then adequately protect man at the point of exposure or at the point of consumption. For example, we can take water for domestic purposes, treat it, disinfect it, and make it satisfactory for consumption. We can take a food product which may have become contaminated, and in the process of handling and cooking we can render it safe. The second principle then is that we can protect man at the point of exposure.

The third principle is that we can take any degree of action needed to protect the public health, virtually the unlimited use of the police powers, no other considerations intervening, to avoid a disastrous effect. This concept is a heritage from almost the middle ages when great sweeping plagues and epidemic disease brought about catastrophic results that called for immediate and drastic action.

But these three assumptions do not hold in California today. Our air problems are not point source problems. Virtually the entire air mass is loaded, and to all intents and purposes loaded on a uniform basis. This is not quite true for parts of the central valley, but it is happening in the major metropolitan areas.

What has taken place in this air mass? Ninety percent of the people in California live in an area where the transparency of the air has been drastically reduced. Eighty percent of our people live in areas where there is a marked detrimental effect on vegetation and agricultural crops of one sort or another. Seventy percent live in an area where many days of the year there is severe physiological discomfort.

One does not have to extrapolate this situation very far to reach emergency proportions. It is not possible to apply classic principles here, because air cannot be treated easily at the point of consumption. We can air-condition a building; we can protect working spaces in industry, and almost certainly we shall see protective air treatment devices on motor vehicles. But then one cannot even contemplate walking through life with a respirator, nor can one contemplate all of the vegetation in this land being grown under glass in a greenhouse.

Police powers cannot be used here in a classic sense, since even in California on the most severe smog days there are no bodies on the street, there are no legal casualties. We cannot apply the classic power of giving an order to an offender to protect a victim--everybody is the offender.

What is the situation with respect to water resources? The State of California is concerned with the quality of all of its water resources--not just the water in domestic systems serving municipalities. All of the water is exposed. It is exposed to pathogens of course, but this situation is easily handled, even though there remains some doubt as to the survival of viruses. The main concern is increasing mineralization--the total mineral burden on the water.

What is the principal source of water mineralization? It is not industrial wastes. The principal source is agriculture, a field in which the use of chemicals has increased the mineral content of irrigation return flows to the point where we cannot tolerate much longer their return to the water supply system.

The stable and persistent organic chemicals have permeated the entire water system of the state. And many are significant not on the level of one part per thousand (approximately the level of concern for total mineral content), but some are significant at a level of only one part per million. Examples are the chlorinated hydrocarbon insecticides that enter the food chains of man or animals and may become highly concentrated.

With respect to human pathogens, our concern is not with the domestic water systems of the state, but rather with recreational waters which cannot be treated. Thus the concept of treatment at the point of use or consumption is utterly illogical. One of our greatest concerns was revealed dramatically by a group of eminent sanitary engineers, three of whom are in attendance at this conference. This was the concern over destruction of the scenic value of Lake Tahoe. Who shall say that this will not be a major public health problem twenty years hence?

What shall we say of the land under the present system of environmental sanitation? Land use has been predicated in California, as elsewhere, on management by individual land owners, many of whom are interested in a quick profit return. There is absolutely no future for the perpetuation of this principle, the classic free market principle, if orderly development and use of the land is to occur.

Let me give you an example: Under the single-owner management system it is impossible to correlate the space requirements going into the use of land by human beings. Consider the space requirement for vehicular transportation. Cities in the United States are influenced considerably by the use of motor vehicles. Considering the motor vehicle, what of the space requirements of the human being? They range from about six square feet per person as we sit in a room such as this, to about 6,000 square feet per person if we are to drive safely at sixty-five miles an hour, one person to a car, on a freeway.

What of the space requirements of a man's home and his premises, of his recreation, of his demand for elbow room for the spirit? How many thousand square feet does a person need to take a pleasant walk along the ocean shore; how many square feet does he need on a hike? How much does he need on a hunting trip? How can these space requirements, biologically essential as they are, be achieved under our present system?

What shall we say of solid wastes under our present system of environmental sanitation?

Without repeating the many things that have been said thus far, I would summarize by saying that the wastes flowing from our food processing plants, of which California has many, represent a shocking waste of the product itself. Do you realize that in a pear packing plant, for example, in the mere act of rotating a knife to peel the pear so that it will not intersect the skin surface at any point, there is removed forty percent of the produce--the fruit, not the tree; this product into which so much human ingenuity and effort went is suddenly shrunk in this mere act because of the assumption that this is a land of plenty and that waste disposal is not a serious enough problem to be reflected in the canning process itself.

What of the household? I think that perhaps the classic story of what happens in our system of handling food is represented by the story of lettuce. Here is a tremendously valuable crop into which a great deal of effort goes, and after many weeks of gentle care and attention the crop is ready for harvest. First of all, in the harvesting, about forty percent of the crop is left in the field. The remaining sixty percent is put on a truck, taken to a shipping point, and again some of the outer leaves are removed, accounting for an additional ten percent loss. Then the lettuce is packed in ice, shipped to the East Coast and the outer layers are again peeled off. Then it goes to the wholesale market. Here there is a man whose job is to go around continually taking off the wilting leaves. Day by day the lettuce shrinks and finally it gets into the kitchen, and the housewife, on the basis of her mother's training, again strips off the outer layer of leaves and puts it into the icebox. Finally comes that one moment for which all of this was prelude, and with tender care a crisp leaf of lettuce is placed on a salad plate, the salad is put on it, and it goes to the table. Then some individual eats the salad and leaves the lettuce.

A disposal method widely used for solid wastes is the sanitary land fill. In California, in the past two years, several cities have been incorporated for the express purpose of preventing the establishment of a land fill. What is a land fill? Fundamentally, it is a way of filling a depression with materials other than earth, and will not become useable land until many years have gone by.

What are the limitations? If one is in fairly level terrain, it is not advisable to raise a "Chinese Wall" by distorting the original topography. Thus in many areas one is reduced to the expedient of filling minor depressions unless one chooses to fill in a flooded area.

A current major issue in California is the preservation of San Francisco Bay. Seldom has there been a movement which so captured and aroused the deep feelings of the population, as the one which proposes to reduce the size of the bay to thirty percent of what it is now. Reflecting upon this, it is not difficult to realize that California may be losing many of the attributes which attracted people there in the first place.

Looking to the future, there are two choices and only two. We can continue the present rear guard action with the certainty of final defeat, or we can determine now that we must adopt a new concept--one with a prospect of permanent success. The key to this prospect is the concept of environmental health (as distinguished from environmental sanitation), which consists of the planned management of natural resources--air, water and land--as a total system. In some areas this can be accomplished on a statewide basis, and in other areas it will be on a multi-state basis.

The geographical common denominator is set by the topography, not by the political boundary. In the case of solid wastes, we must give some thought to converting useless organic materials to a resource of value. We must think of organic wastes as a savings account--a working supply of basic materials, not only for the production of fabrics structural materials and chemicals, but also as a source of carbon, hydrogen, oxygen, sulphur and a few other materials that have the ability to combine, to form plants and animal materials, and which can be broken down and reprocessed.

Why not do as the petroleum industry has done, taking what was originally living plant material that had been reduced by nature to hydrocarbons, and producing a whole catalog of the wonderful compounds that we now call synthetic materials. Organic materials have the potential capabilities of being recombined and re-synthesized into almost living things.

Let us now return to the present and consider the changes in direction that can be brought about under the existing organization. These are the things I foresee: At the beginning of the transition, let us say for the first five years, I see composting and the placing of the compost in a compact fill.

Secondly, I see the combining of all of the organic wastes that I have mentioned--agricultural, industrial and household--to produce a consolidated, stabilized end product that can in turn be used as a raw material for other useful products.

I see, also, changes in the design of food processing plants, an abandonment of the water carriage principle for transporting wastes, and the utilization of these wastes at the processing site, to the degree which at that time seems more intelligent.

I see the elimination of household garbage because of the packaging and marketing changes that will soon bring to your wife's kitchen menu items, if not complete meals, which are one hundred percent edible. Such meals would require only the addition of heat, water, or both, and would have no residue.

In addition, I foresee changes in our marketing and shopping practices, which will eliminate ninety percent of the great numbers of paper boxes, cartons, and different types of containers that serve no useful purpose.

But, before we can go beyond these simple steps, there are two others that must be taken: We must identify and place a price tag on this thing we call the public interest and, secondly, we must invent decision-making machinery that will take into account all of the factors which affect the system that it is attempting to manage.

Concurrent Panel Session

Quantities and Characteristics of Solid Wastes

Group A

Refuse Quantities and Characteristics

Casimir A. Rogus
Director of Engineering
Department of Sanitation
New York City

The three major communal commodity services whose control is essential to life and health of any community are water, sewage and refuse. Although the quantities and characteristics of the first two have been well determined by now, those for refuse are known only partially and then only on a sporadic discontinuous basis for a relatively small number of communities. This incomplete knowledge is distressing in the face of the size and cost of this task and its influence on environmental sanitation and health of the nation. It is estimated that today's output of solid wastes totals about 250 billion pounds (about one billion cu. yds.) with collection and disposal costs approximating 2-1/2 billion dollars annually. The adverse effects on health caused by improper handling have been well established. Extensive research and many cases on record show that diseases, rodent and insect propagation, fire hazards, and air and water pollution, can be traced in many instances to improper management of solid wastes. Polluted air, for instance, has been demonstrated by laboratory and clinical tests to be responsible for several types of respiratory illnesses. These have been corroborated by the well publicized air pollution incidents of London, Donora, Meuse Valley, Yokahoma, Los Angeles and New York City.

The lack of this essential information can be attributed to the following:

1. Complexity of measurement -- whereas water and sewage can be readily metered either at the treatment plant or at the point of usage, refuse with its lack of homogeneity, its variation in density, its many sources of origin (domestic, commercial, industrial), and its multiple systems of collection and disposal, does not lend itself to a simple and complete measurement system.

2. Difficulty in standardizing sampling and laboratory techniques -- here again refuse suffers by comparison with water and sewage. The standards for the latter two are well established. Those for refuse are only now being studied and developed, both here and abroad, but as yet without any generally accepted agreements or conclusions.

3. General failure to recognize the need for this information -- this need has been recognized in Western Europe, and an International Research Group on Refuse Disposal has been active on this since 1958. In this country, however, public attitudes and concerns about solid wastes are usually critical but seldom constructive. The news media are usually indifferent, but on occasion hypercritical. Only the professional person charged with the responsibility of managing the collection and disposal services or for designing such systems gets involved. He however is either not fully knowledgeable about the needs for accurate information -- hence will make little effort to produce it -- or if partially aware of such needs is not in a position to obtain the required data. In desperation he usually will take a stab at it by making assumptions or extrapollations based on whatever meager data he can collect.

4. Geographical distribution -- the size of this country with its great variances in geography, climate, and even living habits has a marked effect on amounts and types of refuse produced. Furthermore, this very size complicates the problem of standardizing and collecting data.

All of these reasons are understandable. The development of measuring, sampling, and laboratory techniques to a common accepted standard is a laborious, costly proposition, requiring a uniform approach to a non-uniform material. The solution to this problem is beyond the purview or capabilities of any one agency or municipality. Only a nation-wide, centrally directed effort will provide the required answers.

The object of this paper is to: (1) define and describe the various solid wastes now extant in this country; (2) discuss the several criteria that effect the quantities and character of refuse produced; (3) review existing knowledge as to their quantities and characteristics; (4) suggest some of the types of information that is required, including reasons therefor.

Definition of Solid Wastes

The discarded materials of a community may be gaseous, liquid or solid. The term commonly applied to solid wastes is REFUSE. Its generally accepted short definition reads "All of the solid wastes of a community including those semi-liquid or wet wastes whose moisture content is insufficient to make the material free flowing." Refuse may be subclassified for purposes of more specific definition, and engineering and legal understandings into garbage, rubbish, ashes, and special wastes. Each of these can be defined as follows:

Garbage -- putrescible wastes derived from the preparation, cooking and serving of foods; from their handling, storage and sale in produce markets; from their handling, processing and storage in abattoirs, canneries and quick-freeze industries.

Rubbish -- non-putrescrible wastes of a combustible and/or non-combustible character normally produced by the community. Typical combustibles are paper, wood and cloth products; rubber, leather and synthetics; garden wastes. Typical non-combustibles are metals, metallic and plastic products, stones and dirt, masonry, ceramic and glass products.

Ashes -- residue, including cinders and fly ash, from burning solid fuels for cooking and heating, and from on-site incineration of refuse materials.

Special Wastes --

a. Street Refuse -- sweepings, litter, leaves and dirt.
b. Demolition and Construction -- lumber, masonry, plaster, piping, conduits, roofing and insulation, excavated dirt and stone.
c. Dead Animals -- cats, dogs, rodents, birds, fish, cattle, horses, and zoo specimens.
d. Out-sized Wastes -- abandoned vehicles, stoves and refrigerators, over-large furniture, tree trunks and stumps, driftwood, palm fronds.
e. Sewage Treatment Works -- screenings, grease and scum, grit.
f. Anotomical and Pathological wastes from hospitals, clinics and medical centers.
g. Industrial (usually self-disposed). These are almost limitless. They range from the quite common cinders and fly ash from power plants to highly specialized wastes of specific industries. They include various hazardous chemicals and chemical by-products, paints, explosives and radio-active wastes.
h. Miscellany -- Christmas trees, rubber tires, various plastic materials, cemetery floral pieces.

Refuse may also be classified by its origin: domestic, municipal, commercial, and industrial. These may be defined as follows:

Domestic Refuse -- includes all those types which normally originate in the residential household or apartment house.

Municipal Refuse -- embraces all the types which originate on municipally owned property. These include street sweepings and litter, catch-basin dirt, refuse from parks, playgrounds, zoos, schools and other institutional buildings; solid wastes from sewerage systems.

Commercial Refuse -- includes all solid wastes which originate in businesses operated for profit such as office buildings, stores, markets, theaters and privately owned clinics, hospitals and other institutional buildings.

Industrial Refuse -- includes all solid wastes which result from industrial processes and manufacturing operations such as factories, processing plants, repair and cleaning establishments, refineries and rendering plants.

Handling Systems

The responsibility for the collection and disposal of these several types of wastes has not been uniformly established. Practice varies with each municipality and is dictated by local policy which, at times, changes with the city's administrations, the city charter, or changes in the city's financial solvency. A general pattern, however, does seem to exist. The collection and disposal of domestic and municipal wastes is normally handled by city forces and facilities. Commercial refuse is most frequently collected by private contractors, but to the municipality's rules and regulations. Its disposal is sometimes made in the contractor's private facilities, but more often in municipally owned facilities on payment of established fees. Industrial refuse is almost invariably the responsibility of the producing companies. They design and operate their own collection and disposal systems but under the minimum controls and regulations legally imposed by a pertinent government agency.

Factors Influencing Quantities and Characteristics of Refuse

At this point it is proper to define "Quantities" and "Characteristics". By "Quantity" is meant the amount of solid wastes produced. Although in the past and to a substantial degree even today quantities are reported by volume -- usually cubic yards -- it is almost self-evident that reporting by weight -- in lbs. or tons -- is the more accurate method. The arguments are:

1. The density of refuse can vary from 100 to 1,500 lbs. per cu. yd. depending on its contents.

2. Refuse of identical composition can vary greatly in unit weight depending on the amount of external moisture such as rain, snow and quenching water.

3. The degree of compaction used in the collection process can double or triple the density.

Similarly, the basic units now used interchangeably to report the amount of refuse produced are lbs. per capita per day and tons per capita per year. Since the amount produced varies seasonally and since it is generated every day of the week (although collection and disposal operations usually operate only five or six days per week) it is suggested that:

1. For purposes of designing collection and disposal systems the probable maximum quantities should be reported in lbs. per capita per calendar day with subsequent appropriate adjustments in designing the plant elements to lbs. per capita per working day.

2. For purposes of comparing the total unit output by a community, the quantities should be reported in tons per capita per year.

The term "Characteristics" as used herein applies to three different classifications:

1. By major component materials such as garbage, paper, textiles, wood, metals, ceramics, plastics, ashes, dust, garden wastes.

2. By physical properties such as density, moisture content, calorific value, size, and sieve analysis (passing 1/4-inch openings).

3. By chemical composition such as carbons, hydrogen, nitrates, phosphates, etc.

The discussion that follows concerns itself with all solid wastes whether domestic, municipal, commercial, or industrial, regardless of their origin and irrespective of the methods used for their collection and/or disposal. The factors which affect the characteristics and their total output for municipal handling are:

1. Number and types of industries and degree to which their wastes are self-disposed.

2. Number and types of commercial establishments and degree to which their wastes are self-disposed.

3. Climate -- to illustrate: in the warm belt the output of ashes will be negligible, whereas the amounts of garden trash may be abnormally high.

4. Seasons -- the winter and holiday months will probably produce higher amounts of textiles and wrappings but less of fresh vegetable and fruit wastes.

5 Income level -- residential areas in the higher income brackets acquire and waste more per capita.

6. Population density -- the high density apartment house areas will generally put out all the wastes they produce (unless they are equipped with on site incinerators) while the individual homeowner will tend to dispose of some of his wastes. Conversely, the apartment house districts will put out fewer leaves, tree clippings, and garden wastes.

7. Technological advances -- developments in food processing such as pretrimming of fresh vegetables, quick-freezing of many types of foods, canning of fruit concentrates, etc., have all contributed to reducing the garbage content to about 1/3 of its previous value -- all within one generation. The ever increasing use of non-solid fuels has almost eliminated the former high ash content. The development of many types of synthetic wrappings and the new systems of pre-packaging of many marketable items have increased the amounts of paper, cartons, and many varieties of synthetic tissue, to a degree where they have more than made up for the reductions in food waste and ashes.

8. Degree of self-disposal -- on-site incineration and garbage grinding does, where used, have a sizeable effect and influence on the amount and character of wastes.

9. Frequency of collection -- where collection schedules are generous the output is untrammeled. Skimpier schedules tend to restain the average output.

10. Fees -- a charge for collection services, usually in direct proportion to the amount of material put out, will invariably reduce the degree of wastage and encourage some self-disposal.

11. Salvaging -- an attractive market for such salvables as paper, rags, metals, or bottles will induce many householders or janitors to cull out these materials from the waste put out for collection.

12. Cost and availability of fuels -- when the cost of fuels for cooking and/or heating is high and they are difficult to procure, the tendency is to utilize some of the combustible refuse for these purposes either in the cooking range, in the furnace, or in the fireplace.

Existing Data

There is considerable evidence that most of the presently reported amounts of solid wastes are considerably below those actually produced. The unit output figures which have been quoted so frequently in engineering literature ranged from but 2.5 to 2.8 lbs. per capita per day. The moisture and garbage content were generally reported too high and the calorific values too low. Little wonder that so many designs were found to be inadequate.

Most of the available information was gathered sporadically and usually for short time cycles by individual municipalities to serve their special needs. In the absence of authoritative guides this information lacked uniformity and consistency. Attempts to use and correlate this information can lead to wrong conclusions and wrong solutions. A study and comparison of the following exhibits is meaningful.

Table 1, taken from Municipal Refuse Disposal, a 1961 publication of the American Public Works Association, shows that the per capita output for the twelve cities surveyed ranged from 794 to 1690 lbs. per capita per yr., the median being 1430 lbs. per yr. Undoubtedly, this wide range was influenced in part by the qualifying factors discussed above, but in part was due, in this writer's judgment, to the absence of uniform standards of sampling and measuring.

Table 1*

Total Refuse Collected in 12 United States Cities, 1957-1958[1]

City	Pounds per Capita per Year	Pounds per Capita per Year
St. Petersburg, Florida	1,690	4.63
Los Angeles, California	1,677	4.61
Washington, D.C.	1,638	4.36
Chandler, Arizona	1,587	4.35
Garden City, New York	1,438	3.94
Hartford, Connecticut	1,430	3.92
Seattle, Washington	1,370	3.75
Omaha, Nebraska	1,370	3.75
New York, New York	1,325	3.63
Atlanta, Georgia	1,252	3.43
Cincinnati, Ohio	1,103	3.03
San Francisco, California[2]	794	2.18

Now compare this with Figure 1. This is a bar graph showing the total amount of refuse delivered for disposal in the City of New York within the last four years. It embraces all solid wastes except for (a) the self-disposed industrial wastes, (b) those wastes going to piggeries and rendering plants, (c) those wastes reduced by the apartment house incinerators to ashes, and (d) certain non-burnable construction wastes going elsewhere. The sum of these, although substantial, is a small percentage of the total. It will be noticed that the refuse produced has been rising progressively from 1200 to 1300 lbs. per capita per year. Nevertheless the spread is small and, in all probability, reflects a true upward trend. The median of 1250 lbs. per capita per year is felt to be quite accurate and representative of today's output in urban areas of over 100,000 population in the northern belt. If all solid wastes of the city were included and a suitable adjustment made for the burn-down in apartment house incinerators this median would approximate 1600 lbs. per capita per year or about 4.5 lbs. per capita per day.

It is felt that these reported values are dependable since:

1. the period covered by the report was continuous, covering all seasons and extended over four full years.

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[1] *Includes refuse actually collected, regardless of the method of collection or disposal. It does not include automobile bodies, cinders, and bones and fats; since they are usually salvaged before collection and sold, they cannot be considered wastes. Apartment house incinerator ash is calculated in terms of equivalent amounts of refuse.*

[2] *San Francisco is set apart from the other 11 cities because it is the only one in which the householder is charged for refuse collection on the basis of quantity. The method of charging is an incentive for the householder to dispose of as much refuse as possible on his premises. Thus the figure for the amount collected is much lower than it is in other cities.*

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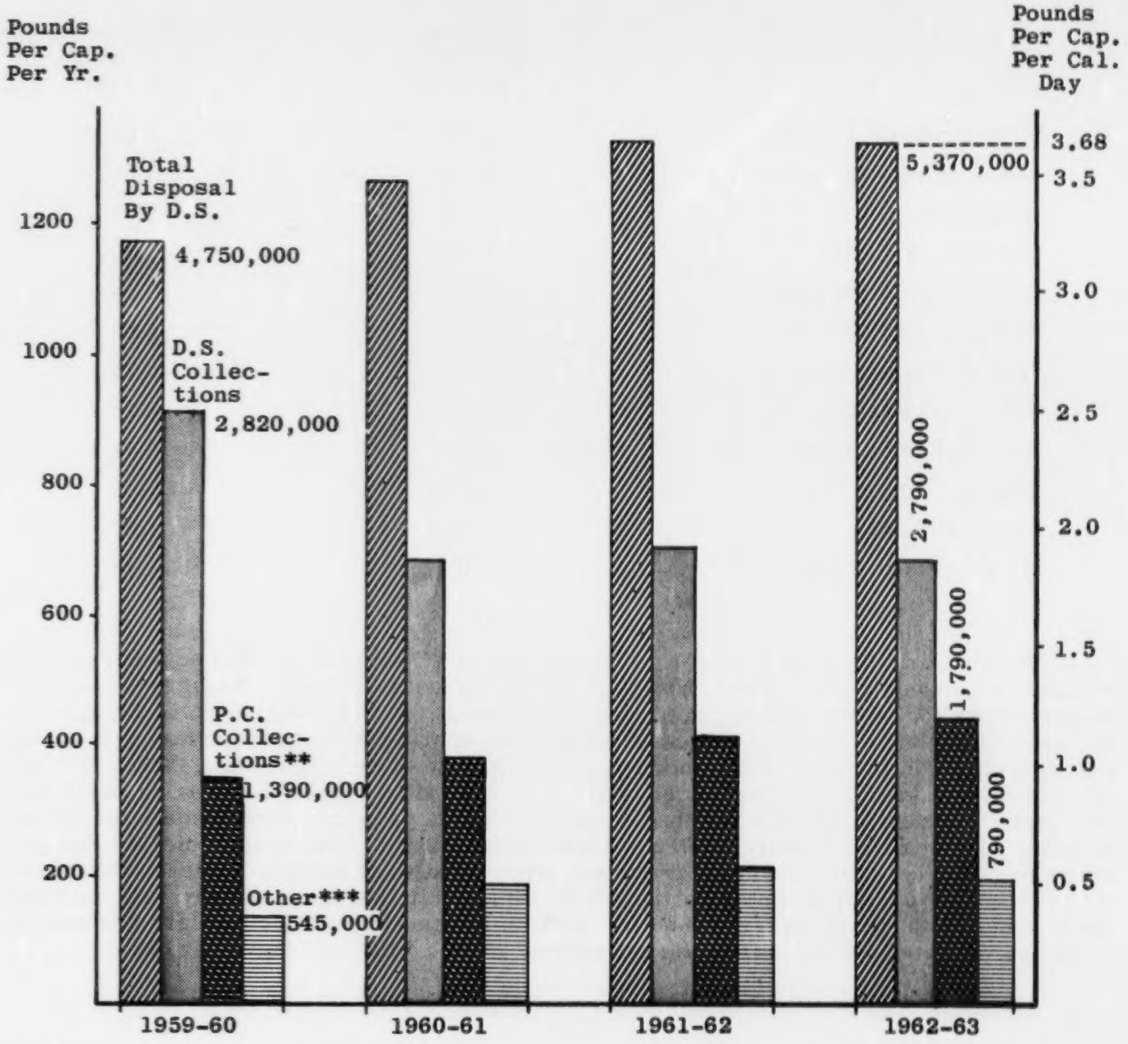
* *From Municipal Refuse Disposal, American Public Works Association, Chicago, Ill., 1961.*

FIGURE 1

ANNUAL TONNAGE RECEIPTS FOR DISPOSAL AT D.S. FACILITIES*
SINCE INSTALLATION OF ELECTRONIC SCALES
1959-60 TO 1962-63



* Disposal quantities at D.S. facilities do not include waste material going to rendering plants and piggeries and self-disposed ashes, construction waste and various industrial wastes all of which are estimated to amount to about 1,000,000 tons annually. D.S. collected residue from apartment house incineration, included in figures used in chart, is estimated as equivalent to about 450,000 tons of refuse.

** Collection of commercial waste by private cartmen.

*** "Other" includes material from federal, state and other city agencies and construction waste. Substantial amounts of burnable construction waste are burned on site. Most non-burnable construction waste is used in private landfilling. Such quantities are not included in this chart.

2. all quantities were obtained from exact weighings on tamper-proof, electro-mechanical, automatic truck scales at each of the 25 disposal locations (incinerators, transfer stations, and truck landfills).

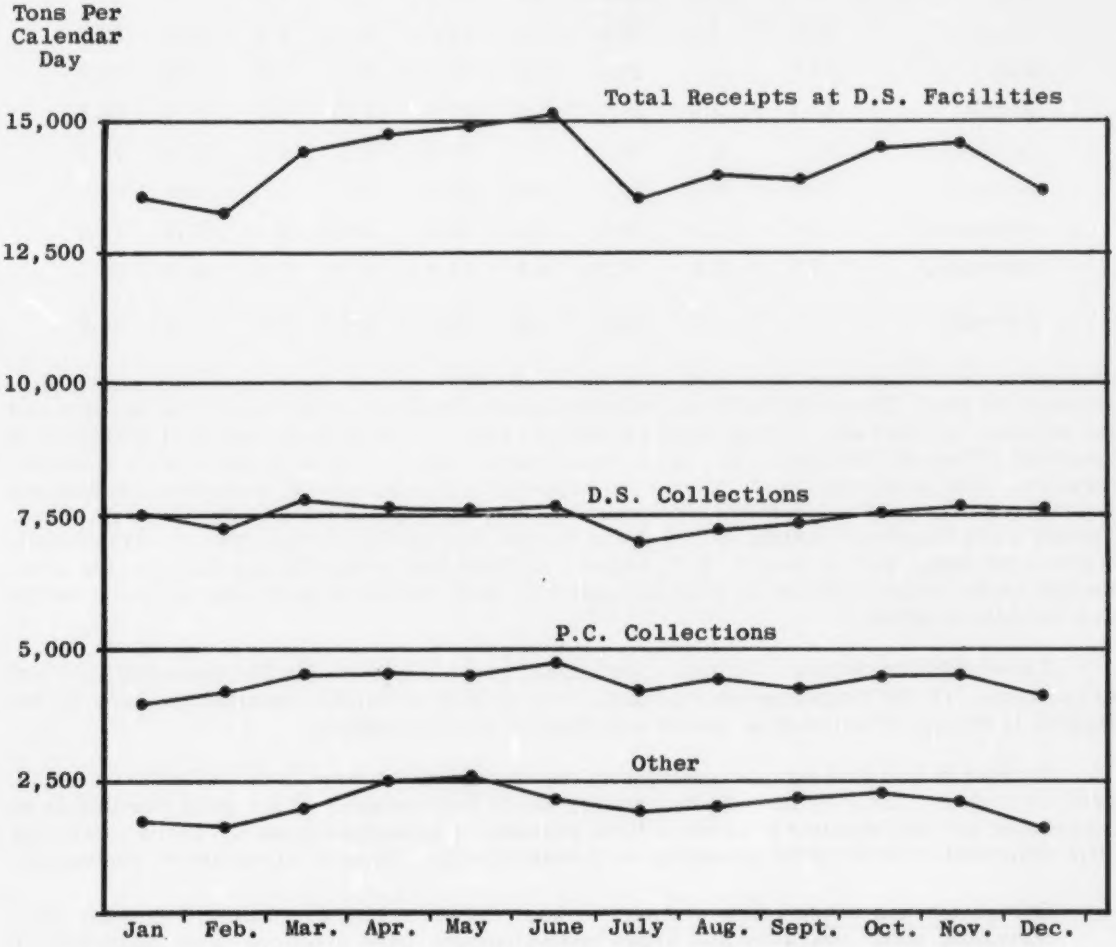
3. the total number of weighings -- well over 5 million -- assures accuracy.

4. the city embraces a complete spectrum of income levels and population densities, and has a representative proportion of residential, commercial and industrial developments.

5. the number of on-site incinerators, garbage grinders, and other self-disposal methods is negligible.

Figure 2 is a graph, again for New York City, showing the monthly and seasonal variations in the total solid wastes delivered for disposal. The fact worth noting is that whereas past

FIGURE 2
SEASONAL PATTERN OF DISPOSAL AT D.S. FACILITIES
AVERAGE TONS PER CALENDAR DAY*
1960 - 1963



*Average monthly tonnage divided by the number of calendar days. See also footnotes to Figure 1.

published reports (for other municipalities) showed many substantial seasonal variations, those for New York City's total mixed refuse show them to be quite mild. The seasonal influences on the separated components might be much more noticeable. To illustrate, let us look at Table 2.

Table 2

Monthly Distribution by Weight of Organic and Inorganic Refuse Disposed of in New York City, 1939

	Per Cent by Weight								
	Organic					Inorganic			
Month	Garbage	Misc.	Paper	Wood	Total	Metal	Glass	Ashes	Total
January	5.7	1.0	12.4	0.3	19.4	4.3	4.0	72.3	80.6
February	9.0	1.7	12.6	0.7	24.0	6.6	4.9	64.5	76.0
March	9.7	2.1	20.6	0.3	32.7	7.4	7.3	52.6	67.3
April	18.1	2.8	21.6	2.0	44.5	7.4	6.9	41.2	55.5
May	26.7	3.3	23.0	3.1	56.1	7.1	6.8	30.0	43.9
June	35.1	3.8	24.3	4.6	67.8	6.4	6.8	19.0	32.2
July	43.8	4.1	25.5	5.9	79.3	6.6	6.3	7.8	20.7
August	23.1	7.4	37.6	3.8	71.9	11.6	5.1	11.4	28.1
September	12.6	5.6	26.7	4.9	49.8	8.2	9.1	32.9	50.2
October	10.1	3.8	31.0	2.6	47.5	8.9	4.0	39.6	52.5
November	6.6	1.9	18.0	2.1	28.6	3.8	2.9	64.7	71.4
December	3.5	0.8	9.0	0.8	14.1	3.1	1.9	80.9	85.9
Average	17.0	3.2	21.9	2.6	44.7	6.8	5.5	43.0	55.3

This shows the breakdown of New York City refuse of 1939 by its major components and by each month of the year. Please note the very substantial seasonal variations then in the garbage and ash content. In contrast, Table 3 which shows the breakdown of Chicago refuse of 1956-58 to a somewhat different itemization of major components, also shows a much smaller seasonal variation. The most significant differences between the two tables are the substantial changes in garbage, ash, and paper content that apparently developed in the intervening 20 years. Thus, Chicago's contemporary content of garbage is but 28% and ash 44% of New York's 1939 vintage, whereas the paper content is over 250% higher. In these two tables the similarity of the components chosen makes a sound comparison possible. Such similarities are the exception rather than the rule however.

These exhibits, selected because of presumed greater accuracies and dependability point up two facts: (1) the disparities in reporting, even in quite accurate presentations, and (2) the benefits to be derived in studying trends and changes over the years.

Another major problem now confronting the larger communities is the collection and disposal of certain relatively new special wastes which have become either quite sizeable as to amounts or are troublesome because of their peculiar or hazardous nature. There exists but little information about their quantities or characteristics. Some of these newer wastes are:

> Demolition and construction wastes -- Last decade's vast programs of highway construction, slum clearance and urban redevelopment have produced huge quantities of burnable and non-burnable wastes. Non-burnables (masonry, rubble, plaster, tile, dirt and stone) being inert are readily disposed without creating nuisances or hazards but do require land or water sites for dumping. The burnables pose a more serious problem.

Table 3*

Physical Analysis of Refuse by Weight -- Chicago, 1956-1958

Date	Number of Samples[1]	Per Cent by Weight Paper	Grass	Garbage	Metal	Glass	Ashes
3/56	10	50.1	. . .[2]	6.4	18.5		25.0
4/56	8	64.0	. . .	7.4	13.9		14.7
5/56	9	57.3	11.9	5.6	14.0		11.2
6/56	6	60.7	6.5	2.5	13.6		16.7
10/56	6	56.0	4.5	3.5	11.9		24.1
2&3/57	4	49.2	. . .	6.1	17.5		27.2
4/57	1	53.3	19.7	3.2	9.3	5.9	8.6
9/57	2	42.0	23.0	3.6	7.4	5.4	18.6
11/57	1	59.3	3.7	2.3	5.2	6.5	23.0
2/58	1	57.6	. . .	5.7	11.6	9.3	15.8
2/58	1	56.3	. . .	1.5	7.5	6.0	28.7
2/58	1	70.4	. . .	2.6	8.0	6.9	12.1
4/58	3	63.7	. . .	1.5	8.1	5.8	20.9
6/58	1	54.7	34.4	0.8	6.2	3.5	0.4
Average		56.5	9.6	4.8	14.8		18.7

Their on-site burning creates air pollution and poses fire hazards. Their disposal at landfills creates voids, provides harborage for rodents, poses future fire hazards, differential settlement problems and probably foundation difficulties. Possible solutions include, (1) at least partial salvage and reclamation, (2) shredding and burning in municipal incinerators under controlled conditions, and (3) burning in bulk in specially designed central incinerators.

Out-sized wastes -- Over-large materials such as furniture, refrigerators and stoves; tree branches, trunks and stumps; driftwood; Christmas trees; abandoned vehicles; rubber tires, etc. cannot be collected or disposed of by normal methods. Special handling methods will have to be developed.

Synthetic wastes -- There exists a limitless number of chemical and plastic wastes including plastic building materials. The degree of their burnability, decomposability, corrosiveness and hazardness is unknown.

Radioactive wastes -- These highly specialized wastes are not, at this time within the purview or responsibility of the municipality. Their handling is generally assumed by special Federal Government Agencies. Should they become in some part a municipal obligation, much information as to their amounts and properties will be needed.

Incinerator residues -- The advent of the ever increasing burning of refuse in various kinds of small and large incinerators is producing ever larger amounts of residuals. Nonetheless very little is known about their exact quantities and composition. Knowledge on their densities, combustible and putrescrible content, the amount and character of metallics, their alkalinity or acidity, sieve analysis and other related characteristics is essential in designing efficient handling apparatus and developing proper disposal methods and possible reclamations.

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[1] *One sample consists of one truck load of refuse (approximately three tons).*

[2] *Analysis for this category not performed; grass included with paper.*

* *From Municipal Refuse Disposal, American Public Works Association, Chicago, Ill., 1961.*

Supplemental Information Required

The development of uniform, standard methods of sampling, and analyzing refuse is essential for planning collection systems, routes and equipment, and for ascertaining, designing and operating the most suitable disposal methods.

Superficially it can be argued that since refuse is such a non-homogeneous material with ever changing characteristics, that more detailed information would be a pointless refinement and that the presently used approximations and parameters for design and operations are adequate. A more thoughtful approach will raise the question as to whether many of the present problems, difficulties and nuisances do not stem from designs or operations which have been handicapped by inadequate data on refuse. This question can be raised as regards both the collection and the disposal systems. It is a matter of record that many existing facilities and systems are either over-designed or under-designed. The former results in needless, over-costly facilities. The operation of the latter usually becomes troublesome and unsanitary. Many an incinerator had to be closed down because of woeful under-capacities and/or intolerable nuisances. Many a refuse dump created health hazards and damaged adjoining property, all because of improper operations stemming from inadequate knowledge about its waste contents.

Even more important, exact knowledge about solid wastes might well lead to complete new concepts pertaining to refuse handling and disposal. The innumerable potential improvements that could result from better information on refuse have been well documented. The following random items are cited only to exemplify the needs and probable benefits.

Scope -- at present much confusion exists as to which of the four types of refuse (domestic, municipal, commercial, industrial) should be included in all basic reporting on quantities and characteristics of solid wastes. The establishment of a single acceptable standard for nation-wide application would solve this dilemma.

Air pollution -- the burning of refuse contributes up to 10% of the total air pollution in urban areas. A great deal of study has shown that these pollutants are in the form of (1) inorganic gases, (2) organic substances, and (3) particulate matter. The physiological effects of these gases and substances have been reasonably well determined. Their relation to many respiratory illnesses is established. Lacking, however, is a thorough understanding of the chemistry of their formation and the specific sources within the refuse which produce these contaminants. Detailed information on these source elements would probably help in developing better burning processes and/or treatment of the effluent gases.

Collection -- the layout of collection routes and their manning with necessary equipment and man-power is largely governed by the probable total refuse output for any given period, its daily and seasonal variations, the differing outputs within the several city zones, and the size, character and type of refuse involved.

The design of collection equipment in turn is governed, in a large part, by the probable compactability, density and size of refuse, the amount of non-compacting dirt and ashes, the extent of highly abrasive and corrosive materials, the amount of rags, wires and other similar materials which tend to foul up the loading and compacting mechanisms, and the presence of such hazardous materials as glass, paint containers, fluorescent tubing and others.

Reclamation -- one of the reasons for the abandonment of the previous avidly practiced salvaging operations stems from a lack of knowledge on the specific needs of the potential customers for such items as waste paper, metals, and rags. Out of the 30 million annual tons of waste paper and paper products produced, a substantial portion could be recovered if specific information was developed on their characteristics, on the types of treatment required, and the methods of possible re-use were developed. Similarly, more detailed knowledge on the composition and characteristics of the 5 million annual tons of used tin cans and the 1-1/2 million tons of other wasted metals could enhance their potential sorting and processing and help develop resale markets to fill the needs of a number of potential users. Analogous approaches on the other salvable components might in addition help to initiate a conservation program and, at the same time, reduce the total amounts requiring final disposal.

Incineration -- thermodynamic calculations require specific information on the amounts of combustibles, their densities, moisture and calorific values, availability of carbon, hydrogen and oxygen, etc. Their abrasive and corrosive action on grates, refractories and other materials must be considered. Dust and putrefiable contents are essential guides in the design of ventilating systems. In each instance the median, lower and upper limiting values are necessary.

Information on the range of sizes, a sieve analysis of the fines, and amounts and types of wires, bars, rods and similar materials should be obtained beforehand and given consideration in designing the handling and loading mechanisms. For instance, the writer is painfully aware of the failure and subsequently required write-off of a $250,000 conveyor system largely because the latter items were not taken adequately into account in its design. It is also probable that the dirty, dusty conditions generally observed in incinerator operations stem from designs which fail to appraise the extent and character of dust in mixed refuse.

Landfills -- a knowledge of the density and compactability of the refuse to be dumped can guide sounder estimates on the area, space needs and useful life of given sites. Its putrescible contents can help anticipate and so prevent or at least control near-future odors or long-range methane gas production. The possibilities of polluting sub-surface water aquifers by future leachates could also be foretold. The future designs of possible structures and their foundations require the establishment of permissible unit soil pressures and pile bearing loads. All of the above and much more can be reasonably predicted if the composition of refuse is known in advance.

Other disposal methods -- in each instance it can be demonstrated that a much more effective design and a more efficient operation will result when the peculiar needs of the given method are appraised in the light of specific information as to the characteristics of the refuse to be processed. One instance that comes to mind concerns composting. Although the details of the several types of processes are well known and the principles of biochemical digestion for normal refuse are well understood, there has been little published recognition given to date to the ever increasing content of the many types of modern plastics and synthetics, most of which are non-compostable.

Conclusions

It can be concluded from the above that:

1. There now exists a lack of consistently dependable knowledge of refuse quantities and their seasonal and yearly variations and changes.
2. There is a similar lack of information as to their characteristics, and physical and chemical properties.
3. Practically no information is available on some of the newer special wastes. Among these are demolition and construction wastes, miscellaneous outsized materials, various chemical and synthetic discards, and some of the newer hazardous wastes including radioactive materials.
4. The absence of this essential information largely exists because the required overall nation-wide development of uniform standards of measurement and of analysis has not been made to date.
5. Lacking this detailed information the designs of existing facilities have been handicapped as to their effectiveness and efficiency and generally result in costlier and less sanitary operations.
6. A concentrated nation-wide effort could develop and establish the necessary information to guide improvements on existing systems and facilities and to promote more efficient future designs and operations.

Characteristics of Municipal Refuse

John M. Bell
Assistant Professor of Sanitary Engineering
Purdue University
Lafayette, Indiana

It is reported (1)* that in 1901 M. N. Baker made the following statement:

> "In no branch of municipal service has so little progress been made in the U.S. as in the disposal of garbage. Why do such conditions exist? First, because the sanitary collection and disposal of garbage is appreciated neither by the general public nor the city officials; second, because it is seldom recognized that the problems incident to final disposal are largely engineering in character and therefore should be entrusted to engineers."

Mr. Baker's statement could be enlarged in scope by substituting the term refuse for garbage. Also, emphasis should be placed on the need for engineering technique and administration in collection of municipal refuse as well as in disposal methods.

Thirty-four years later, in 1935, the Sanitary Engineering Division of the American Society of Civil Engineers appointed a "Committee on Technical Aspects of Refuse Disposal" (2). This Committee was expected to "stimulate and develop, by studies, reviews, and discussions of refuse collection and disposal problems, a more adequate and impartial engineering basis for this field of sanitation." At the end of four years, in 1939, the final report of the Committee stated that: "due to the unusual activity of members of the Committee and on account of the lack of general interest in the subject under consideration at this time. . . . . . it is recommended that this Committee be discontinued."

It is reported (1) that this "unusual activity" of Committee Members and a lack of general interest throughout the country remained up until about 1947, at which time there apparently was a realization of the necessity for solving a municipal problem which places increasing demands on public officials and engineers. Consequently, there was a definite increase in activity in research, design, and operation in the field of refuse collection and disposal. This led to an extensive program of literature emanating from individuals, colleges, institutions, and commissions.

A review of this literature several years ago indicated, however, that our knowledge of the physical and chemical composition of refuse is surprisingly meager. The reason is that municipal refuse is not just complex in its composition but also extremely variable in both quantity and quality due to such factors as geographical location, season of the year, changing economical and social living conditions, methods of collection, frequency of collection, and the like.

In order to learn more about the nature of this material it was essential that a reliable and standard sampling procedure be developed so that representative samples of refuse could be obtained for analysis and study. Although there had been a number of isolated studies of the physical and chemical composition of refuse, there existed no standard or fully acceptable method of sampling municipal refuse. Aware of the need for the development of such a procedure, the National Institutes of Health sponsored a project a Purdue University directed toward the development of reliable methods of refuse sampling and analysis.

In keeping with the theme of this Conference; namely, a summary of the present status of the present status of the art and a stimulation of research on pertinent problems in the field, the following topics will be discussed: 1) Present methods of sampling and analyzing municipal refuse; 2) Present research; and 3) Recommended future studies. All research reported in this paper will deal with the work done at Purdue during the last six years toward the development of a practical and reliable technique for sampling and analyzing municipal refuse.

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* Numbers in parentheses ( ) refer to the appended references.

Methods of Refuse Sampling and Analysis

Field Studies

The first two years of the project at Purdue dealt principally with various sampling methods for determining the composition of a large quantity of refuse, such as a truckload of approximately 8000 pounds. Samples of refuse for this part of the study were received from Chicago, Illinois, Baton Rouge, Louisiana, and West Lafayette, Indiana. Results indicated that one has 95 percent confidence of being no more than 20 percent in error by analyzing a quarter of a truckload of refuse when estimating such parameters as percent by weight, percent by volume, bulk density, percent moisture, percent ash, and calorific value of the garbage, combustible, and non-combustible portion of the refuse.

Also included in the first two-year study was a sampling procedure at West Lafayette in which samples were obtained on a household basis in order to show the variation in quantity and quality of refuse from individual households throughout a homogeneous residential area within a community. Altogether a total of 654 separate refuse collections were made. The refuse collected amounted to 9,669 pounds and it was produced by 2,260 persons as determined by a census of each household sampled.

The weight and volume of the refuse samples from each household was determined and then converted to a pounds per capita per day and cubic feet per capita per day basis, respectively. A statistical analysis of the data then gave some idea of the necessary number of households to be sampled in a homogeneous area of a community in order to obtain a desired accuracy with a certain percent confidence. For example, it was found that in order to determine the parameters of pounds per capita per day, pounds per household per day, cubic feet per capita per day, and bulk density, the number of samples (1 sample equal to 1 household) required to obtain accuracies of 10 percent deviation from the mean (confidence level equal to 95 percent) is approximately 175.

The initial work done in connection with sampling on a household basis produced various recommendations for further investigation. These led to a concentrated effort to develop a reliable sampling procedure for cities of various size.

Individual refuse sampling projects were conducted in cooperation with four cities in the U.S. Midwest during the period from August 1959 to April 1962. These cities were (population given in parenthesis): Milwaukee, Wisconsin (734,788); Toledo, Ohio (315,000); Bloomington, Indiana (23,573); and Indianapolis, Indiana (476,248). A total of 2400 refuse samples were obtained and analyzed.

Field studies were conducted in order to obtain samples of refuse for laboratory analysis as well as to estimate the accuracy of the method used in obtaining these samples. Sample areas were selected by stratified random sampling after the city had been classified into high, medium, and low socio-economic strata on the basis of housing and/or property market value. The total quantity of refuse produced by the population in these sample areas was collected by a special crew either on a routine basis or periodically throughout the year. Estimation of the total city refuse was obtained by simple extrapolation of the sample data on a weighted basis for each of the socio-economic strata. Periodic weighings of the total city refuse allowed the determination of the percent error of these estimates. The average percent errors for the four cities are presented in Table 1. Also shown are the sampling ratios (population of all sample areas divided by total city population) used in the four cities. These ratios ranged from 0.0244 in Bloomington to 0.0006 in Milwaukee.

Table 1

Average Percent Errors and Sampling Ratios

City	Number of Estimates	Sampling Ratio	Average Percent Sampling Error
Milwaukee	50	0.0006	6.95
Indianapolis	3	0.0025	4.74
Toledo	6	0.0139	2.73
Bloomington	8	0.0244	2.24

Significant differences were found in the average percent error of these estimates between all cities except between Toledo and Bloomington. The apparent non-significance between these two cities was not entirely unexpected because their sampling ratios were relatively closer than those of the other cities.

A logarithmic relationship was found between the sampling ratio and the average percent sampling error. A linear regression analysis was made by the method of least squares. The linear regression equation, for the indicated range of sampling ratios, was found to be:

$$Y = 0.122 \ e^{-0.781 X}$$

where, Y = sampling ratio, expressed as a decimal

X = percent sampling error

e = base of natural, or Naperian, logarithm

This equation can be used to estimate either the sampling ratio, Y, or the percent sampling error, X. For example, suppose that a particular percent error does not wish to be exceeded, then an estimate of the sampling ratio can be made by using this percent error in the equation. Having obtained a sampling ratio, the total sample population can then be determined since the total city population will be known.

In some cases it may be desired to predict a percent error from a certain sampling error. That is, suppose it is determined that only a certain number of samples (or total population of sample areas) can be used in a city of known size. This would allow a calculation of a maximum sampling ratio. Using this value in the equation, the percent sampling error can be estimated.

It is recommended that the use of the equation be limited to the range of values of both variables given in Table 1, and that no attempt be made to extrapolate the regression line (given by the equation) beyond these values.

With the exception of Toledo, the total population of the sample areas in the cities was between 400 and 1200. It is recommended that at least 400 people be used as a total sample population when conducting a refuse sampling study. In other words, a city whose total population was 20,000 could probably not use a sampling ratio of, say, 0.0006 and expect to obtain the accuracy indicated by the equation. This would mean that only 12 people would be included in the sample. Not only would such a size sample be intuitively "non-representative," but it would be quite difficult to select. If the city is initially sub-divided into, say, three socio-economic areas, and two blocks of approximately 25 homes were chosen in each of these areas, then, on a basis of 3 people per home, approximately 450 people would be included in the sample population.

A statistical analysis of the data obtained from the field studies with respect to the parameters of pounds per capita per day and cubic feet per capita per day indicated a significant difference (at 95 percent confidence level) between the high, medium, and low socio-economic classifications as well as between the various seasons of the year.

Laboratory Sampling Technique

A total of approximately 70,000 pounds of refuse were received from Milwaukee, Toledo, Bloomington, and Indianapolis during the period from August 1959 to April 1962. Samples of 40-60 pounds of garbage and remaining combustibles from each of the sample areas in these cities were sent to Purdue via motor freight. To have maintained this amount of material, even after drying, in the laboratory for a long enough period until various chemical analyses could have been conducted was, of course, not possible. Therefore, only a portion of each sample was retained, thus necessitating a further sampling procedure.

Preparation of the material received from the various cities, except Milwaukee, where grinding and drying of the combustible portion of the refuse was already performed, was as follows:

The entire quantity of each material received was shredded with a modified Allis-Chalmers forage harvester until a maximum size of 2-3 inches was obtained. Upon completion of shredding a "representative" sample of from 1000 to 3000 grams of the material was selected and placed in a tared plastic container and dried to constant weight at 70° in a forced-air-draft oven. Weighings were made both before and after drying to determine the percent moisture of the material. The dried material was then ground in a standard laboratory-type Wiley Mill to a maximum size of 2 millimeters. This material was then stored in an air-tight, labeled can until needed for chemical analysis.

In order to estimate the accuracy obtained in the sampling of the shredded material, duplicate samples were selected and analyzed at four different times throughout the survey period. The analyses that were performed on the duplicates included percent moisture, percent ash, and percent nitrogen. The data indicated that a greater accuracy is obtained in the sampling of the garbage than the paper; where the garbage is unwrapped and the paper refers to the remaining combustible portion of refuse.

In addition to the selection of a sample after shredding of the material, a sample had to be selected from the dry material stored in the can each time a chemical analysis was performed. The question then arises, how "representative" is this small quantity, in some cases as small as 2.0 grams, of the entire material in the can? A number of duplicate analyses were performed on various samples throughout the year in order to estimate the accuracy of the selection of a sample at this stage of the over-all sampling process.

Using a confidence level of 95 percent and a sample size of one, the following statements can be made about the percent sampling errors of the two sampling techniques employed in the laboratory:

Paper Samples

1. One has 95 percent confidence that if a sample is selected from the initially shredded material, the sampling error of the sample obtained for subsequent analyses will not exceed 7.5 percent.
2. One has 95 percent confidence that if a sample is selected from the dried and ground material, the sampling error of the sample obtained for a chemical determination will not exceed 4.8 percent.

Garbage Samples

1. One has 95 percent confidence that if a sample is selected from the initially shredded material, the sampling error of the sample obtained for subsequent analyses will not exceed 6.0 percent.
2. One has 95 percent confidence that if a sample is selected from the dried and ground material, the sampling error of the sample obtained for a chemical determination will not exceed 2.8 percent.

Calculations were performed in order to estimate the over-all sampling error for the combination of the two laboratory sampling techniques; namely, the resultant sampling error due to the original sample being sampled at two stages. The following probability statements are presented:

1. One has 95 percent confidence that, if only one sample is selected from the initially shredded paper material and this sample is, in turn, subsampled after drying and grinding to obtain a final aliquot for a chemical determination, the over-all sampling error will not exceed 10.3 percent.
2. One has 95 percent confidence that, if only one sample is selected from the initially shredded garbage sample and this is, in turn, subsampled after drying and grinding to obtain a final aliquot for a chemical determination, the over-all sampling error will not exceed 7.2 percent.

It is emphasized that the values stated in all the above probability statements are subject to the conditions that were present during the laboratory tests; namely, size of samples, size to which material was ground, and the like.

Methods of Laboratory Analyses

A special study was conducted in the early part of the project in order to obtain information concerning the laboratory technique of drying and grinding refuse samples prior to subsequent chemical analyses. For example, it was found that a drying temperature of 70° C was optimum, as compared to the conventional 103° C, in order to prevent the volatilization of various constituents in the material; in particular, the petroleum ether extractables (lipids).

It was also determined that two to five (2-5) percent of the moisture in a garbage sample may be lost if the sample (about 70% moisture) is initially ground in its "wet" state before it is dried for moisture content determination. Likewise, that approximately 0.8 percent of the moisture in a garbage sample (about 70% moisture) is not measured if the material is merely dried to constant weight from its initially "wet" state. However, if the material is initially partially dried, then ground, and then finally dried to constant weight, this additional percent moisture will be obtained.

Recommended methods of chemical analyses for the combustible portion of refuse were developed during the refuse project at Purdue. The analyses include: moisture, volatile solids and ash, lipids, liquid content, sulfur, nitrogen, carbon, hydrogen, carbon-nitrogen ratio, phosphorus (P_2O_5), potassium (K_2O), gross calorific value, and net calorific value.

Several of the methods resulted from repeated modifications of existing methods in order to allow for the peculiar nature of the material being dealt with. In some cases more than one method was developed for a particular analysis. The number of analyses developed was by no means exhaustive; however, it is believed that they are the basic ones necessary for the design of any of the popular methods of disposal of municipal refuse.

The individual methods of analyses will not be presented herein. They may be found in either of two publications; namely, (1) Bell, John M., "Development of a Method for Sampling and Analyzing Refuse," PhD Thesis by John M. Bell, Purdue University, January 1963, or (2) Municipal Refuse Disposal, Appendix A, American Public Works Association, Chicago, Illinois, 1961.

Because of the amount of time required (45 minutes to one hour) to determine the carbon and hydrogen content of a sample with an electric-furnace-combustion train, this method was not feasible during the project in view of the fact that over 3200 refuse samples were to be analyzed over a 4 year period. A review of the literature revealed that an emperical formula, called the New Zealand Formula (3), had been developed for rapid determination of percent carbon in a synthetic garbage. In the formula the percent carbon is determined by its emperical relationship with the percent volatile solids (100% - % ash) of the material. The relationship is as follows:

$$\%\ \text{Carbon} = \frac{100 - \%\ \text{ash}}{1.80}$$

In view of the simplicity of this method, a study was made to investigate the applicability of such a formula for the material that was being analyzed. Over 200 samples were selected to be tested for percent ash and percent carbon, as well as percent hydrogen, in order to develop similar emperical "factors" for the determination of both carbon and hydrogen. The results indicated that one has 95 percent confidence that the error in the estimate of the carbon and hydrogen content from the following emperical formulae will not exceed 8.0 percent:

Raw Garbage: % C = (100 - % ash)/1.97
% H = (100 - % ash)/12.8

Remaining Combustibles; % C = (100 - % ash)/2.18
% H = (100 - % ash)/14.7

Total Combustibles: % C = (100 - % ash)/2.08
% H = (100 - % ash)/14.4

Miscellaneous Study

In 1956 the American Public Works Association conducted a survey of all cities in the United States having a population of 5,000 or more (4). The "blanket" questionnaire sent to each of these cities did not incorporate any inquiry as to the type or frequency of refuse analyses, if any, being conducted by these cities. Likewise, no information was obtained from the survey concerning the laboratory facilities of these cities for conducting such determinations as moisture, ash, and calorific value on refuse samples. Because of the lack of this information and the usefulness of such, if future studies were to include the use of various cities throughout the country to investigate the quantity and quality of refuse produced in various areas of these cities, a survey was conducted in order to learn exactly what is being done and/or the available facilities to conduct certain analyses.

The survey consisted of sending a brief questionnaire to all cities in the United States having a population of 100,000 or more. Several cities of lesser size were included in the survey. A total of 119 cities were contacted. Ninety-five cities (80%) replied. The results indicated the following facts:

1. Only 3.2 percent of 95 of the larger cities in the United States conduct refuse sampling procedures on a routine basis.

2. Only 19 percent of 95 of the larger cities in the United States have their own laboratory facilities for determining either ash content or moisture content.

3. Only 9.5 percent of 95 of the larger cities in the United States have their own laboratory facilities for refuse grinding or determination of calorific value.

Current Research

Indianapolis Study

Many cities throughout the country are adopting the plan of prohibiting backyard incineration of refuse in order to alleviate the air pollution problem. Still other cities are having the problem of not having a type of refuse that will support its own combustion during incineration. Faced with either or both of these situations, a municipality would, of course, be interested in determining the increase in quantity of refuse to be handled should backyard incineration be banned or a campaign be started to obtain more combustible material from the public.

A special survey was initiated with the City of Indianapolis in order to investigate this very situation. During a six-week period in Nov.-Dec. 1962 and a five-week period in August 1963, the householders of the sampling areas used in the previous years study were given special 20 gallon containers and asked if they would please put out all of their refuse. Ninety-five and one-half percent accepted the cans. A record of the cans actually put out, however, indicated only about 70 percent usage.

During one week in each of the sampling periods the refuse from the total city was weighed. Based on an extrapolation of the sample areas to a total city basis, the 1962 survey indicated that there would result a 100 percent increase in the quantity of refuse to be handled. The 1963 survey indicated a 35 percent increase. As expected, both studies indicated that the increase in quantity was primarily due to an increase in the combustible portion of the refuse.

Special Laboratory Study

An investigation is presently being conducted in order to determine more accurately, if possible, the precision of sampling the dried and ground material in the laboratory for chemical analyses. A better estimate of the sampling error could be made if there was some way to determine the chemical content of the entire original quantity of material. It is, of course, out of the question to try to determine the percent lipids, for example, of some fifty to one-hundred pounds of wrapped garbage. The same would be true for any other of the chemical analyses. In spite of this seemingly impossible task there is a procedure that should not prove too time consuming nor expensive. This procedure is presently being carried out and is described briefly as follows:

A large amount (100-150 pounds) of the sample is placed into a "Total Body Liquid Scintillation Counter" and the gamma radiation of the isotope K^{40} is measured. The total amount of potassium (K) can be calculated by the use of the relative abundance of 0.0119 % by weight of K^{40}. The sampling errors involved in the sampling technique can then be determined by comparing the above determination of K with that by the laboratory analysis on the same sample.

The determination of the K^{40} isotope is not readily measured in this type material. Work is being done with respect to internal standards and geometry factors. Preliminary studies, however, seem to indicate that this method might be acceptable as a means of determining the error involved in sampling approximately 2 grams out of 100 pounds of refuse.

Recommendations for Future Research

In the interest of continuing and furthering research on refuse sampling, the following recommendations for further studies are made:

1. To date, a study of refuse sampling procedures has been limited to only a relatively few cities. The four principal cities used in the Purdue Project were of different size and the sampling procedures involved different sampling ratios and approximately equal number of sampling areas. In order to determine whether any of these factors are interrelated, it is recommended that refuse sampling studies be conducted in:

   a. Cities of the same size - but different sampling ratio.

   b. Cities of different sizes - but same sampling ratio.

   c. Cities with a different number of sampling areas, or stratum, and with the same number of sampling areas for the cases of a and b.

2. It is recommended that the percent sampling errors be investigated in cities with a sampling ratio above and especially below the range of ratios that were used by the four cities reported herein; i.e., above 0.0244 and below 0.0006.

3. The sampling procedure presented herein was developed from and is to be for domestic refuse only. Although this material is usually the bulk of a cities refuse, there is always some amount of commercial and industrial solid wastes to be handled. In those cities where service to these establishments has been taken as a responsibility of the city, the problem of disposal can be of considerable magnitude to city officials. It is therefore recommended that further studies be conducted in order to develop a reliable sampling procedure for determining the quantity and quality of refuse from commercial and industrial establishments.

4. Limited work was done at Purdue with respect to determining the labor requirements of a sampling procedure. More information about the actual labor and cost involved in a refuse survey for various cities would be desirable.

5. It has been suggested (5) that a solid waste testing program be undertaken to obtain data on the quality and quantity of refuse produced in various cities throughout the country. A mobile testing laboratory has been suggested for conducting such a program. Should it be decided, however, to process the samples at several specific locations, it is suggested that some study be made as to the best type of shipping containers and mode of transportation of the samples.

6. The tentative methods of refuse analysis as published in the APWA book Municipal Refuse Disposal are not all inclusive, nor are they beyond further refinements. Additional studies are suggested in order that some type of "Standard Methods for the Examination of Municipal Refuse" might be formulated.

Conclusion

Substantial knowledge about the physical and chemical composition of refuse is essential if we are to 1) design the most effective collection methods; 2) choose the most efficient disposal systems; and 3) design this system to operate at optimum efficiency. Furthermore, as an economic aspect of the situation, it is becoming increasingly important that, as a nation, we recover all materials of possible value from our refuse. A better understanding of the chemical composition of refuse will enable us to design more efficient recovery methods for utilizing part or all of the refuse as part of a planned conservation program.

It is an archeological truism to say that a civilization is known by the refuse it leaves. We have reached the point in our development at which we might with greater emphasis say that our civilization will have to make its mark by the refuse it eliminates.

GENERAL DISCUSSION

CHAIRMAN ROGUS: I am sure we all have a lot of questions and reservations about what has just been discussed, but before we open the meeting to general discussion I would like to raise what to me is a key question about this whole business. The key question is this: Whereas many of us seem to recognize the need for uniform sampling and analysis of refuse, few cities take the trouble to do this. Does this mean that perhaps we theoreticians, so to speak, are stressing things that perhaps are not practical?

The mere fact that here we have by far the smallest conference group indicates to me that perhaps there isn't as much interest in or recognition of this particular need as some of us would think.

MR. KAISER: There is a definite need for such data. For example, a city council may ask, if they are wise, how many more incinerator plants will be needed in the next ten years. You can't just pull that answer off the top of your head and convince them.

To put it the other way, if you see that your present plants are becoming overloaded and that more plants are needed, you have to have some pretty solid data to make projections and justify the expense, because other groups in the city are going to be making similar studies in their areas and will also need funds. So, right off, your methods of presenting your requests must be very sound.

There is also the case of equipment designers, who until now have been using very simple rules. For example, one might consider refuse as cellulose with a heat value of 8,000 BTU per pound, and allow 25 percent moisture and about 25 percent residue, and do all the designing on that basis. But the heat value of cellulose is not 8,000 BTU per pound, and refuse is not all cellulose. If you want to go further, a gas analysis should also be done. This is difficult. I have looked at a lot of gas analyses and it appears that natural gas and fuel oil are burning in the incinerator rather than cellulose. I haven't found one yet that is really burning cellulose.

The more we know, the better we can design for a proper air supply. You can't just oversize the fans and then cut everything back as needed. Competition is tough in this game, and you have to be able to justify the sizes of air ducts, fans, and other items. In boiler design, which is ahead of incineration, they have gone to considerably more precision in analyzing fuel consumption and air rates. If we ever get to steam generation in refuse--and it has been done to some degree--we will have to know a lot more. We can do a lot of designing without knowing more about refuse, but it won't be long before we are going to need more data.

Another deterrent to cities making their own studies is that they expect incinerator manufacturers to have all the data. All the cities need are some figures on tonnage, and designers supposed to know how to handle it. You and I know they can't.

CHAIRMAN ROGUS: You mentioned power generation. This involves a homogeneous fuel which, within very small limits is fairly consistent in calorific value and other properties. Therefore, the design is relatively simple.

But refuse is a fuel that not only changes from day to day but changes from season to season. It changes from year to year. What is more, Chicago refuse is different from Los Angeles refuse.

MR. KAISER: All the more reason for having these analyses. You have just made a start. I would want to know how wet this material is going to be, and what are the moisture limits.

CHAIRMAN ROGUS: Would you design to the maximum moisture?

MR. KAISER: Yes. If the moisture is at a certain level, and there is a certain amount of grass and wet leaves, and so on, I would design with preheated air to handle it. If the noncombustibles --tin cans, bottles, wire, and so on--are sometimes going to go as high as 35 percent of the material charged, and there is a specified tonnage, then the grate or residue handling system must be designed to operate over the whole year.

CHAIRMAN ROGUS: But an engineer does not design a structure--be it a building, a sewer, or an incinerator--for obvious economic reasons, for the worst possible conditions.

MR. KAISER: You are the customer, and you must specify the design limits. If they are exceeded, then all of the tonnage cannot be burned.

DR. TAIGANIDES: What is the variation in refuse production from city to city? Is it possible to determine a reliable design value?

PROF. BELL: It is not possible to predict how much refuse is produced in a city of a given population. But with the sampling procedure, you can find out very easily, with a minimum of expense and effort, what you need to know. Such procedures can be modified or changed somewhat, and can be used on a continuing basis. In other words, surveys can be conducted periodically and can be kept up to date. For example, if the income brackets in a city were approximately 33-33-33, high, medium and low, you would want an equal number of samples in each of these areas. If the city could only be broken up into two categories, high and low, and the proportions could definitely be broken into a 60:40 relationship, then the sampling could be proportioned accordingly.

DR. TAIGANIDES: Thus you would not only have to take a sampling on the garbage, but you have to sample the income of the people as well.

PROF. RYCKMAN: I would like to say that in my opinion and experience, our present sampling and characteristic determination procedures are certainly not too academic or too complicated. If anything, they have been too simplified. What have the rest of you found to be the main problem in determining the quantities and characteristics of refuse? Haven't most of the lay people in city councils, governments of cities, and professional people--including the M.D.'s and even the consulting engineers--felt that we have in the past known more about quantities and characteristics than the present research has indicated?

In other words, the study reported by Mr. Bell gives us some indication of the kinds of errors we can expect to encounter in dealing with weights and volumes of refuse produced. With these procedures we can determine design values for, say, Indianapolis or Milwaukee, but we cannot extrapolate these to Los Angeles.

PROF. BELL: That is correct.

MR. WASSON: I would like to get some idea of the income variations you are talking about. Is the ratio of refuse produced by high income groups to low income groups 2 to 1 or 3 to 1?

PROF. BELL: In quantity it may be two, three or four. In quality, for example in Bloomington, the refuse is 75 percent noncombustible. A consulting engineer has designed an incinerator for that city. Seventy-five percent noncombustible go into that plant and more than 75 percent are going to come out.

CHAIRMAN ROGUS: There must be a safety factor in the design. Taking the case just illustrated, if it is found that 75 percent noncombustibles is incorrect and the actual value is only 50 percent, the factor of safety is inadequate.

MR. KAISER: I have just passed around a sheet that I would like you to look at. Mr. Bell was very kind to send me data that helped to make up this story. It shows the different constituents of municipal refuse. If you accept the first column showing the various percentages of these the result will be as shown at the bottom.

Table 1

Composition and Analysis of an Average Municipal Refuse

	Per cent of total refuse	Proximate Analysis* "As received" basis, weight per cent.				Ultimate Analysis, Dry basis, weight per cent.								Btu per lb	
		Moisture	Volatile Matter	Fixed Carbon	Non-** Comb.	Carbon	Total Hydrogen	Available Hydrogen	Oxygen	Nitrogen	Sulfur	Non-** Comb.	Ratio C:(H)	Dry basis	Dry, ash-free basis
Rubbish, 64%															
Paper, mixed	42.0	10.24	75.94	8.44	5.38	43.41	5.82	(0.28)	44.32	0.25	0.20	6.00	155	7572	8055
Wood and bark	2.4	20.00	67.89	11.31	0.80	50.46	5.97	(0.672)	42.37	0.15	0.05	1.00	75	8613	8700
Grass	4.0	65.00	--	--	2.37	43.33	6.04	(0.83)	41.68	2.15	0.05	6.75	52	7693	8250
Brush	1.5	40.00	--	--	5.00	42.52	5.90	(0.75)	41.20	2.00	0.05	8.33	56.7	7900	8600
Greens	1.5	62.00	26.74	6.32	4.94	40.31	5.64	(0.77)	39.00	2.00	0.05	13.00	52.4	7077	8135
Leaves, ripe	5.0	50.00	--	--	4.10	40.50	5.95	(0.31)	45.10	0.20	0.05	8.20	131	7069	7700
Leather	0.3	10.00	68.46	12.44	9.10	60.00	8.00	(6.56)	11.50	10.00	0.40	10.10	9.1	8850	9850
Rubber	0.6	1.20	83.98	4.94	9.88	77.65	10.35	(10.35)	-	-	2.0	10.00	7.5	11330	12600
Plastics	0.7	2.00	--	--	10.00	60.00	7.20	(4.40)	22.60	-	-	10.20	13.6	14368	16000
Oils, paints	0.8	0.00	--	--	16.30	66.85	9.65	(9.00)	5.20	2.00	-	16.30	7.43	13400	16000
Linoleum	0.1	2.10	64.50	6.60	26.80	48.06	5.34	(3.00)	18.70	0.10	0.40	27.40	16	8310	11450
Rags	0.6	10.00	84.34	3.46	2.20	55.00	6.60	(2.70)	31.20	4.62	0.13	2.45	20.4	7652	7844
Sweepings, Street	3.0	20.00	54.00	6.00	20.00	34.70	4.76	(0.36)	35.20	0.14	0.20	25.00	96	6000	8000
Dirt, Household	1.0	3.20	20.54	6.26	70.00	20.62	2.57	(2.07)	4.00	0.50	0.01	72.30	10	3790	13650
Unclassified	0.5	4.00	--	--	60.00	16.60	2.45	(0.166)	18.35	0.05	0.05	62.50	100	3000	8000
Food wastes, 12%															
Garbage	10.0	72.00	20.26	3.26	4.48	44.99	6.43	(2.845)	28.76	3.30	0.52	16.00	15.8	8484	10100
Fats	2.0	0.00	--	--	0	76.70	12.10	(10.70)	11.20	0	0	0	7.2	16700	16700
Noncombustibles, 24%															
Metallics	8.0	3.00	0.5	0.5	96.0	0.76	0.04	(0.02)	0.2	-	-	99.0	51	124	12000
Glass and ceramics	6.0	2.00	0.4	0.4	97.2	0.56	0.03	(0.02)	0.11	-	-	99.3	34	65	8000
Ashes	10.0	10.00	2.68	24.12	63.2	28.0	0.5	(0.40)	0.8	-	0.5	70.2	70	4172	14000
	100.0														

Organic Analysis of Composite

	Per cent
Moisture	= 20.73
Cellulose, sugar, starch	= 46.63
Lipids(fats, oils, waxes	= 4.50
Protein, 6.25N	= 2.06
Other organic (plastics)	= 1.15
Ash, metal, glass, etc.	= 24.93
	100.00

Analysis of Composite Refuse, As Received Basis

Moisture	Carbon	Total Hydrogen	Available Hydrogen	Oxygen	Nitrogen	Sulfur	Non-Comb.	Ratio C:(H)	Btu per lb
20.73	28.00	3.50	(0.71)	22.35	0.33	0.16	24.93	39.4	4917
								Btu, dry	6203
								Btu, M and AF	9048

*Based on ASTM methods of analysis of coal and coke, as adapted for refuse.

**Non-combustibles-- ash, metal, glass and ceramics.

Similar analyses can be made for any city. If the moisture is higher due to uncovered cans, or something of that kind, the analyses can be adjusted accordingly. The values shown may be somewhat outdated, since I would say that on the average we now have less garbage and more paper than shown here. This is the kind of information that a designer must know in developing combustion equipment. I am spending $1,000 to analyze a number of refuse samples in an effort to get more information. We record the proximates, ultimates, and BTU values.

MR. BELL: If anybody is interested in obtaining a copy of our step-by-step procedure for sampling a residential area of a city, I will be glad to send it to you. It is outlined in the December 1962 issue of THE APWA REPORTER.

CHAIRMAN ROGUS: In summing up this session, it is the sense of this meeting that refuse analysis and sampling should be further developed and established throughout the nation.

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Agricultural Solid Wastes*

E. Paul Taiganides
Assistant Professor, Agricultural Engineering Department
Iowa State University
Ames, Iowa

The trend in livestock production is to automation. This is particularly exemplified by the recent history of confinement rearing of poultry and swine. During the last few years, many of the problems associated with livestock and poultry production within a confined area have been satisfactorily solved. Consequently, many farmers are changing from pasture to pen confinement. In this manner, the full advantages of central feeding, push-button operation and small land area use per animal can be better utilized.

The trend to confinement production is firmly established. In the poultry industry, units housing over one hundred thousand birds have been in operation for quite some time now. Those who are close to the swine industry indicate that, in the near future, by far the majority of hogs will be raised in confinement units, each capable of marketing from 3,000 to 10,000 hogs per year. For example, in Red Oak, Iowa, pilot units designed to market 10,000 hogs per year are now marketing 15,000, and a 10-year expansion to 100,000 hogs per year is anticipated. The number of dairy and beef cattle per farm is increasing with correspondingly less area per animal.

The largest single problem in confinement production involves manure handling and disposal. The odor and fly nuisance of manure, the large quantities produced daily, the decline of manure as a competitive fertilizer and the encroachment of urban areas to production units complicate the problem of livestock and poultry waste handling, treatment and disposal.

Although manure disposal is the most vexing problem, there are other sources of agricultural wastes whose handling and disposal can be just as problematic. In a recent discussion by agricultural engineers of the problem of waste management (10);** five distinct sources of rural wastes were pointed out: 1). Human wastes from America's 4 million farm and 8 million non-farm families. 2). Livestock manure wastes estimated at 50 billion cubic feet per year. 3). Crop residues such as sugar cane, corn stalks, pea vines, tree prunings, etc., amounting to 8 tons of plant wastes for each American family (9). 4). Wastes from rural industries such as creameries, fruit-packing sheds, canneries and packing houses, and 5). Residues from agricultural chemicals. To this list, the problem of disposing of 30 million dead birds per year should be added. Even under good management, the average mortality rate in hen production is about 1 percent per month. This means the disposal of 1,000 birds per month from a 100,000 laying hen production unit.

The problem of manure handling and disposal is not only more vexing, but it is also of more general concern than the other agricultural wastes. Table 1 shows that the 1961 farm animal population of the United States is three times greater than the human population. If the population equivalent figures as given by Eby (5) for hogs, 1.9, cattle, 16.4, chicken, 0.014, are applied to the 1961 population totals given in Table 1, the wastes from the swine, chicken and cattle alone are equivalent to 10 times the wastes from the human population of the United States and 100 times greater than the wastes from the rural human population.

According to Hart and McGauhey (9), the number one technical problem facing the livestock and poultry producer is manure management. This is particularly true around the urban

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* *Approved as Journal Paper No. J-4738 of the Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa, Project 1433. The study was supported in part by U. S. Public Health Service Research Grant EF 00410-01, Thamon E. Hazen, Principal Investigator and E. Robert Baumann, Co-principal Investigator.*

** Numbers in parentheses ( ) refer to the appended references.

Table 1
Farm Animal Population of the United States*
(All figures in thousands)

	Hogs		Poultry		Turkeys		Cattle	
Region	Average 1951-1960	1961	Average 1951-1960	1961	Average 1951-1960	1961	Average 1951-1960	1961
North Atlantic	1,200	984	66,931	56,872	429	324	5,451	5,366
East North Central	16,143	17,056	70,634	57,219	554	773	14,247	14,290
West North Central	24,042	24,933	101,921	82,691	1,008	1,686	27,412	27,412
South Atlantic	5,134	4,678	44,519	51,160	608	669	7,054	6,978
South Central	6,809	6,452	63,702	58,907	842	925	22,301	23,890
Western	1,429	1,340	47,193	53,727	1,942	2,393	16,151	17,328
United States	54,757	55,443	394,900	360,576	5,384	6,770	92,616	97,319

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* *Taken from Agricultural Statistics (2).*

areas, which, since World War II, have expanded into the rural production areas. Besides the Odor nuisance and fly-breeding problems, untreated manure is a health hazard to both animal and man. Table 2 gives a partial list of diseases that are common to man and beast, and their control and abatement is of concern to public health officials. On the other hand, the producer is limited in his efforts of manure management both by lack of information and funds. The farmer is willing, more than is generally accepted, to adopt new ideas to combat the waste disposal problem. However, new ideas are slow in coming from the engineers and scientists in the field.

Little basic research has been done on methods of manure disposal. Virgually no information on manure management is found other than in the popular press. Technical papers based on research are nonexistent. Recognizing this deficiency, the Research Advisory Committee of the 13 Land Grant Universities of the North Central Region recently placed first priority for initiating research in farm waste handling and disposal.

Properties of Agricultural Manures

Physical Characteristics

Production process. The physical and chemical properties of animal wastes are affected by the particular characteristics of the animal, the feed ration and the environment. The size of the animal as measured by its live weight is perhaps the most important parameter. The sex and breed of the animal affect the manure properties to the extent that they determine to some degree the feed conversion efficiency under a given environment. Temperature perhaps is the most important of the environmental factors.

The quality of the feed influences not only the amount the animal or hen eats daily which will be reflected in the quantity of manure produced, but also influences the chemical composition of the manure. The constituents of the feed undergo highly complex chemical changes as they pass through the digestive tract of the animal. These changes are brought about by the enzymes of the digestive fluid and the bacteria which inhabit the intestinal tract of the animal. Starch and sugars are highly digestible, hemicelluloses and celluloses are somewhat less digestible, while the lignins are highly resistant and hence tend to be accumulated unaltered in the feces.

Proteins, which contain most of the nitrogen of the feed, vary in digestibility depending on the source of the protein. The nitrogen of the undigested proteins is excreted in the solid feces, whereas the nitrogen of the digested proteins is absorbed and is later excreted in the urine, ex-

Table 2
Some Infectious Diseases Common to Animals and Man*

Disease	Animals Affected	Mode of Infection
Actinomycosis	All domestic animals	Chewing contaminated straw, etc.
Brucelosis	All domestic animals	Direct contact & consumption of contaminated dairy products
Gas Gangrene	All domestic animals	Infection of wounds
Glanders	Horses, mules	Contact
Leptospirosis	Swine, cattle, rats, dogs	Contact - swimming in infected water
Swine Erysipelas	Swine, turkeys, sheep	Infection through skin
Tetanus	All domestic animals	Contact - wounds or manure, filth
Tuberculosis	Cattle, swine, fowl	Contact and ingestion
Pox	Cattle, horses	Contact
Q Fever	Cattle, sheep	Inhalation of contaminated dust
Rabies	All domestic animals	Bite or wound
Newcastle Disease	Chicken, Turkeys	Infected fowl or careless handling of vaccines

* *Taken from Midwest Farm Handbook (15).*

cept for a small portion used to build flesh in the animal. The potassium in the feed is absorbed during digestion, but practically all of it is excreted in the urine and in the fecal matter. Part of the phosphorous content of the feed is absorbed, but most of it is excreted in the feces. Furthermore, some of the feed is spilled on the pen floors and is included in the manure collected from the animal pens. Therefore, the wastes from animals in a confinement building will contain all the ingredients of the feed, some of them in their original form, others in a chemically simpler form. Table 3 shows a corn and soybean meal hog ration and its constituents.

Table 3
Calculated Analysis of the Ration Fed to Hogs Reared in Confinement at Iowa State University*, **

Item	Units	Protein Content 12%	14%
Protein Nitrogen†	%	1.92	2.24
Fat	%	3.39	3.18
Fiber	%	2.89	3.13
Calcium	%	0.505	0.675
Phosphorus	%	0.455	0.531
Copper Oxide	ppm	187.5	250.0
Vitamin A	IU/lb	878.7	816.6
Vitamin B_{12}	Meg/lb	3.75	5.0
Vitamin D_2	IU/lb	159.8	213.0
Riboflavin	mg/lb	1.69	2.11
Pantothenic Acid	mg/lb	4.79	5.73
Niacin	mg/lb	14.78	16.55
Choline	mg/lb	296.7	349.3
Autofac	mg/lb	7.5	10.0
Iron	ppm	52.7	70.4
Cobalt	ppm	1.2	1.6
Zinc	ppm	61.7	81.6
Manganese	ppm	43.3	57.8

* *Data for this table were taken from Reference (21).*

** *Typical feed ration constituents and their digestibility can be obtained from feed manufacturers and numerous publications (such as 15, 17).*

† *Based on 16 percent nitrogen content for protein.*

The manure should also be rich in bacteria cells which inhabit the digestive tract of animals and are excreted in the feces. In general, 75 percent of the nitrogen, 80 percent of the phosphoric acid, 85 percent of the potash and 40 percent of the organic matter of the feed can be expected to be recovered in manure from mixed classes of livestock (20). With animals that are neither growing nor decreasing in weight, such as a mature horse, the recovery of the fertilizing constituents in the manure is practically 100 percent. The nitrogen excreted in the feces and urines of the animals is not always in a form readily attacked by soil microorganisms. The lignin portion of the feed tends to combine with proteins to form compounds that are highly resistaht to biological decomposition, particularly under anaerobic conditions (26). Bacterial decomposition of manures can also be inhibited or limited to some extent by the accumulation in manures of feed constituents that are used in the feed as antibiotics. Copper oxide, which is included in some hog rations (see Table 3), can accumulate to toxic levels in manure and inhibit anaerobic digestion of manure (21).

In summary, it can be stated that most of the feed ingredients of the animals will be excreted in the feces and urine. The amount of each feed constituent found in manure depends on the size and kind of animal, its condition (laying hen vs broilers, or milking cow vs a steer), the environmental temperature and the feed conversion and water consumption of the animal. On the basis of these parameters, the quantity and composition of manure can be estimated theoretically (21).

Daily production. The quantity and composition of animal wastes depend so much on the feed ration and the environment in which the animals grow that it is difficult to evaluate figures given in the literature unless the feed ration and the environmental conditions are given. Furthermore, values obtained 10 or 30 years ago were not determined under the same conditions that the animals are raised today, nor were the animals fed rations of the same composition as today. Unfortunately, most of the work in this area was done 20 to 30 years ago when the fertilizer value of the manures was considered competitive. Today's farm labor costs and relatively inexpensive commercial fertilizers do not make manure field application economically feasible (3), even where land is available. Moreover, most of the figures on manure found in literature include bedding which is no longer used in confinement production. The values for manure production reported in this paper do not include bedding or litter.

Table 4 gives the daily production of manure of farm animals as reported in the literature and as found by the author. There is considerable variation in the values given in Table 4. This variation can be attributed not only to the reasons already mentioned, but might also be attributed to the difference in what the values represent. For example, the manure production value of 5.0 lb. per day per 100 lb. hog determined by the author does not represent the average manure defecation by a 100 lb. hog. Instead, it represents the amount of manure that can be expected to be collected from daily scraping of pens with hogs averaging 100 lbs. in live weight. As such, this figure is of more value to the person designing a treatment plant for the wastes. It is not clear in the literature whether the rest of the values given are defecation rates or actual quantities scraped off the floor and transported to a central point for disposal.

The daily manure production in a confinement unit varies with the time of year. In the Iowa State University hog confinement studies (24), it was found that during the summer when the air temperature in the building averaged 80°F, the amount of manure collected was 3.9 lb. per pig. During the winter and spring, when the temperature averaged 53 and 64°F, the quantity of manure scraped off the pen floors was 5.9 and 6.3 lbs. per pig, respectively. These variations in daily manure production with the time of year are significant in that they must be considered in the design of a treatment process which requires a constant flow of manure.

If it can be assumed that the variation noted in Table 4 in the values given for daily manure production reflect the inherent variability among the breeds of animals and the variability of growth conditions throughout the United States, the average of all the values might be considered as representative of the daily manure production. On that basis, the average daily manure defecation will be as given in Table 5. The values of Table 5 should be used only as guide lines and not as design figures for a given production unit.

Total solids. There is a greater variability noted in the figures for dry matter content of the manures when these figures are expressed as percent than as lbs. of total solids per day.

Table 4
Average Daily Production and Composition of Farm Animal Manures

Animal	Animal size or age	Manure Total lb/d	Total %	Solids lb/d	Volatile Solids % DB	Fertilizing Constituents N % WB	N lb/d	P_2O_5 % WB	P_2O_5 lb/d	K_2O_2 % WB	K_2O_2 lb/d
SWINE											
25	100 lb.	8.4	13.0	1.09	-------	0.50	0.042	0.35	0.029	0.40	0.034
20	-------	9.5	12.6	1.20	-------	0.54	0.051	0.34	0.032	0.65	0.062
8	100 lb.	2.8	28.2	0.80	-------	-----	------	------	------	-----	------
12	-------	9.3	17.8	1.66	87	-----	------	------	------	-----	------
24	100 lb.	5.0	17.0	0.85	83	1.20	0.060	------	------	-----	------
HENS											
25	5 lb.	0.12	45.0	0.05	-------	1.00	0.0012	0.80	0.0010	0.40	0.0005
18	4-5 lb.	0.39	25.0	0.10	-------	1.47	0.0057	1.15	0.0045	0.48	0.0019
8	5 lb.	0.14	48.0	0.07	78	-----	------	------	------	-----	------
22	4-5 lb.	0.20	24.1	0.05	73.8	1.61	0.0032	------	------	-----	------
27	4-5 lb.	0.38	24.0	0.09	79.2	1.48	0.0056	0.96	0.0036	0.47	0.0018
TURKEYS											
27	5-18 lb.	0.75	26.0	0.19	77.8	1.31	0.0098	0.71	0.0053	0.49	0.0037
CATTLE											
8	1000 lb.	38.5	27.2	10.5	-------	-----	------	------	------	-----	------
25	1000 lb.	74.0	14.0	10.4	-------	0.60	0.444	0.15	0.111	0.45	0.333
20	-------	72.0	13.2	9.5	-------	0.50	0.360	0.16	0.115	0.38	0.274
6	1000 lb.	71.3	16.0	11.4	-------	0.49	0.349	0.15	0.107	0.48	0.342

Using the lbs. of total solids per day from Table 4 as the basis for calculation, the total solids content for the wastes is as given in Table 5.

Volatile solids. Information on volatile solids content of animal wastes is scarce in the literature reviewed. In the past, researchers looked at manure from the standpoint of its fertilizer value and, thus, did not investigate the organic matter in manures.

Table 5
Guide Values for Average Daily Manure Production and Composition*

Item	Units	Hogs	Hens	Turkeys	Cattle
Wet Manure	Lb/d	7.0	0.25	0.75	64.0
Total Solids	%	16.0	29.0	26.0	16.0
Volatile Solids	%	85	76	78	80**
Nitrogen	% db	4.5	5.6	5.2	3.7
P_2O_5	% db	2.7	4.3	2.8	1.1
K_2O	% db	4.3	2.0	1.9	3.0

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* *Based on the average of figures reported in Table 4.*
** *Taken from Table 17, Reference (12).*

However, on the basis of work done by Hart (8) and the author (22, 24), the volatile solids content of the manures is placed between 75 and 85 percent, dry basis. According to Reinhold and Noak (19), the total solids content of pig manure was 26.2 percent during the winter period, when the pigs were raised in confinement and were fed on grain rations, and 18.7 percent during summer, when grain feeding was supplemented with pasturing of the hogs. They found the volatile solids content to be 62.0 (16.2 percent, wet basis) and 81.4 (15.2 percent, wet basis) percent for the winter and summer periods, respectively.

Chemical Characteristics

Fertilizing constituents. Because of the emphasis in the past on the fertilizer value of animal wastes, considerable work has been done to determine the fertilizing constituents of these wastes. Table 4 shows the nitrogen, phosphoric acid and potash content of the manures from the given animals. It may be noted in Table 4 that poultry manure has the highest fertilizer value, with swine manure coming second. However, it takes about 100 hens to produce the same amount of nitrogen as one cow. On the basis of 10, 12 and 5 cents per pound of nitrogen, phosphoric acid and potash, respectively, the value of the manure nutrients would amount to $27 for a 1,000-pound dairy cow and $36 for 200 hens per year. However, one would have to have about 12 tons of dairy manure and about 9 tons of poultry manure. On soils of good tilth, the value of the manure lies only in its nutrient content. However, on soils of poor tilth, animal manures have an added value as soil conditioners because of their organic matter content.

BOD, COD and PE. There is a wide disagreement in data pertaining to the Biochemical Oxygen Demand and the Population Equivalent of animal wastes. Part of the disagreement can be attributed to the difference in manure production figures reported in the literature.

Henderson (11) reported the population equivalent of domestic animal wastes based on calculated BOD and on two baselines, the human excrement baseline and the domestic sewage baseline. Table 6 shows the population-equivalent figures reported by Henderson (11) and Eby (5).

Table 6
Population Equivalents of Animal Wastes*

Species	Dry-Weight Basis	BOD Basis		C/N Basis
		Human Excrement Baseline	Domestic Sewage Baseline	
Man	1	1	0.55	1
Hog	26.1	1.6	0.9	1.9
Hen	1.50	0.32	0.17	0.014
Turkey	4.97	----	----	------
Cow	114.5	6.4	3.5	16.4

* *As reported by Henderson (11) and Eby (5).*

Taiganides, et al (24) found the BOD and COD of hog manure (fecus and urine mixed) to be 0.54 and 1.20 lbs. per pound of volatile matter, respectively. Jeffrey, et al (12) reported values of 0.30 and 1.56 for BOD and COD of hog wastes, respectively. The difference may be attributed in part to the fact that Jeffrey, et al determined the BOD and COD of the feces and urine separately. They found the feces to exert a BOD of 0.26 lb. per pound of total solids, and a BOD of 0.27 lb. per pound of dry matter in the urine of hogs. According to Henderson (11), the normal constituents of urine are not considered to contribute significantly to the carbonaceous BOD of the wastes.

Hart (7) reported a BOD of 0.015 lb. per hen per day and a population equivalent of 12 chickens per human. He found the BOD rate constant, K, of chicken manure is 0.13, indicating that chicken manure decomposes slightly faster than does sewage under aerobic conditions and has slightly lower ultimate BOD.

The pH of all fresh manures is favorable for biological decomposition; it ranges from about 7 to 8.

Manure Disposal Practices

Although many of the problems associated with the control of the animal environment in a confinement unit have been solved satisfactorily or are being researched intensively, no really satisfactory method of manure treatment and disposal has been advanced. The main methods of disposal which are being practiced in the United States include field spreading, lagoons and composting. In other parts of the world, sludge digestion with methane recovery and sprinkler irrigation are also being tried.

The predominant method in the north central United States is field spreading. Field spreading of untreated manure has several limitations. With the increasing concentration of animal production units near markets and processing centers, land available for spreading is becoming scarce. About 250 acres of land are needed each year for the disposal by field spreading of the wastes from a confinement unit in which 5,000 hogs are reared annually. A poultry unit housing 50,000 hens will produce 6 tons of manure per day. At a maximum rate of soil application of 8 tons per acre, the land required would be about 270 acres. Even if such land was available to the producer, he would still require some storage facilities because he would be limited by the crops raised and the conditions of the fields; i.e., the operator will be limited by the weather in his field spreading operations. Furthermore, untreated wastes spread on fields can contribute significantly to stream pollution (11).

Much has been written in the popular farm press about anaerobic lagoons, but lagoons are not the panacea they have been described to be. They are not applicable where land is porous, water is scarce, or near urban areas where the odor evolved could become a nuisance to the nearby dwellers. Furthermore, no design criteria for lagoons have been developed from actual experimentation. Most all farm lagoons have been constructed with no consideration given to the characteristic of the animal wastes involved. Thus, many of the farm lagoons are underdesigned and are functioning more like septic tanks (14). Although lagoons located underneath slotted pen floors or next to the confinement buildings have been labeled as the cheapest method of manure disposal (16), much research needs to be done to develop design requirements.

Only large producers or cooperatives could afford composting of manures, according to Wiley (28). In Europe and Africa, sludge digestion of animal wastes has been investigated intensively and is being used to some extent. The high initial cost of digestion equipment and relatively inexpensive commercial fertilizer and power available to the American farmer make the method of sludge digestion applicable to large production units only (23). Some other methods which have been studied and have met with some success are "hydraulic collection systems" (1,4), dehydration and incineration (13) and thin spreading (8).

The variety of farm waste disposal methods advanced indicate that no one method has been found satisfactory. This lack of one or more generally accepted methods of manure disposal is due to the inherent limitations of the methods practiced, the lack of experimental data on these methods and to some extent on the variability of conditions from one farm to the next.

Discussion and Conclusions

The problems associated with farm waste handling, treatment and disposal have been compounded with the recent trend in confinement rearing of livestock and poultry production. Livestock and poultry confinement housing units with population equivalents of 10,000 to 20,000 are already in existence, and their number is steadily increasing. Furthermore, the lack of engineering information on manure disposal, the encroachment of urban areas to previously rural regions, the scarcity of land for disposal and the characteristics of the manures themselves complicate the problem of agricultural waste management.

Although manure disposal is perhaps the number one problem in livestock production, there are five other distinct sources of agricultural wastes whose handling and disposal can be just as problematic. These include human wastes from the rural population, crop residues, wastes from rural industries, agricultural chemical residues and disposal of 30 million dead birds from poultry production units.

The physical and chemical properties of the farm manures were reviewed and guide values for the major properties were presented. An analysis of the present methods of manure disposal showed that no really satisfactory method of farm waste disposal has been advanced. The farmer is willing, more than he generally accepted, to adopt new ideas to combat the waste disposal problem. However, new ideas are slow in coming from the engineers and scientists in the field.

GENERAL DISCUSSION

MR. PROCTOR: I noticed a figure of .25 pounds of wet manure per hen per day. We have come up with a figure of .35 pounds per day which we are collecting on plastic sheets. It never accumulates at the site. This amounts to 6,350 tons per year of wet manure that a farmer with 100,000 birds has to handle. I think this is rather an impressive figure, particularly if you are standing on it.

MR. GENETELLI: At Rutgers we have an average of about 1/2 pound per day per chicken, and for milk cows it averages 60 to 100 pounds per day, depending of course on the size of the cow. In New Jersey we have a peculiar problem because of the urban encroachment on farm areas, so there is confinement of chickens. New Jersey is a big egg producing state. There are 100,000 birds on the average farm, and all the methods of treatment that were mentioned, such as field spreading, lagoons, and so on, cannot be used. There is no land area available for the farmer.

Another thing; Most farmers want to get rid of the handling problem entirely. They want automatic handling. They don't want hand removal, so they use either mechanical removal or water carriage. When you are dealing with 100,000 birds, water carriage requires a great deal of water.

MR. PROCTOR: I have heard that in the Los Angeles area, big farms (and they have to be big in order to operate at all) are operating on a 3/4 cent per dozen profit margin on eggs. You don't have to increase much on waste treatment to knock that out, or the fellow will be out of business. He is not willing to operate in the red for 30 years. He is better off not operating at all.

PROF. LOEHR: There is a point here that we frequently overlook. This is a really big industry. We have caused other industries to change their waste handling and sludge problems. We have thought of farming for many, many years on an individual basis. It is no longer that. It is a tremendous industry now, and I think we have to change some of the thinking within the field along these lines.

True, they are operating on 3/4 cent per dozen profit in this case, but still this has to be equalized across the country. Perhaps all these organizations could handle their wastes together as an industry and still make money.

PROF. CURRY: Is there any good data on the composition of this material?

DR. TAIGANIDES: I think our biggest problem is a lack of data. Because of this we have had difficulty in designing a system or method for handling this waste. For example, at Iowa State we did some studies on digestion, and we thought we would get a tremendous amount of methane gas because all the ingredients were there. But we found that this was not the case, the high copper content (220 p.p.m.) of hog manure was fouling up the digestion and inhibiting gas production. By diluting the sludge and taking out some of the copper, we greatly increased methane production.

Some work has also been done in determining the BOD of this waste. For hogs, the BOD population equivalent ranges from zero to 0.9, 1.9, and 2.3. Those are individual figures. Which one is correct? Many investigators have determined the BOD per unit of manure and then would take someone else's figure for manure production and the population equivalent would be much different. For example, practically everyone designs for 9 pounds of manure per hog per day.

This figure was determined in 1912. It was used in the 1939 Yearbook of Agriculture, and again in the 1957 Yearbook of Agriculture. Nobody knew it was taken in 1912. Just recently it was stated, "it is well established that the unit production of a hog is 9 pounds per day." This gives a population equivalent of 4. We don't really know the true value. The significance of copper and zinc and the amounts present have not been determined.

There are also tremendous variations in the amount of manure produced and in its composition, but the data is very scant.

MR. PROCTOR: In determining the BOD of poultry manure, we found that seeding it with raw sewage caused a 35 percent difference in the BOD value. In other words, if you depend on the organisms present in the manure to do the decomposition, you get one value; if you supply them with other organisms, you get an altogether different value.

CHAIRMAN ROGUS: Since all of this material seems to be so potentially rich in its value as a compost or as fertilizer, have any producers indicated an interest in converting this material into a saleable fertilizer?

PROF. LUDINGTON: There have been many companies that have tried and have operated successfully for a short period of time, and then for some reason their success ran out. The quantities produced are an important factor. In one county in New York State there is more organic material produced from poultry than is at the present time consumed on the entire Eastern Seaboard. The supply so far exceeds the demand that this does not appear to be the answer. In the case of compost, if we were to compost even half of the refuse produced in the United States and divide it up among the farmers, the farmers could not possibly consume all of it.

CHAIRMAN ROGUS: That is an extremely interesting point to me, because we have been talking for years about composting refuse, which basically does not compare in its potentials with this rich material. Why waste our time and effort discussing composting of refuse when we should be concerning ourselves with this other problem?

MR. PROCTOR: One problem is that demand is out of phase with the supply. The farmer doesn't spread fertilizer in the middle of winter. But that doesn't stop the cow and chicken; they keep right on going.

CHAIRMAN ROGUS: One of the basic discussions is that shipping and spreading costs are much less for the concentrated synthetic fertilizers. On the other hand, the natural fertilizer has the virtues of soil conditioning and moisture. Would compost be useful in the southern states? What about the arid regions--the sandy soils of the Carolinas?

DR. TAIGANIDES: There you would have value. For example, in The Netherlands they need manure for reclaiming their land.

MR. PROCTOR: Each soil is different. In some places there might be an advantage, probably not from a nutritional standpoint but to change the texture of the soil, possibly to make it more manageable.

PROF. BELL: I would like to comment on the disposal of these agricultural wastes. Indiana is a state that has many hog farms. About six months ago a member of the Agricultural Engineering staff came over to us and asked if we had any information that would help them in the design of hog lagoons. As Dr. Taiganides has mentioned, they seem to be dropping away from the idea of farm spreading. Sludge digestion isn't the best method, but something must be done. It is very simple to dig a hole and flush a little water in it. The result is a hog lagoon. Since the Agricultural Engineering Department at Purdue is closely allied with the various county agents who have been getting a demand for literature on design procedures for hog lagoons, they came to us for information.

We feel that the hog lagoons are anaerobic and that the process taking place is similar to ordinary digestion. A graduate student is working with me on this at the present time. There are varying ways of loading these lagoons. Some lagoons are extended right up under the pens. The hogs are raised on slotted floors and the droppings fall in. It was reported a month ago that the ventilation system went out in one hog pen and 168 hogs were asphyxiated overnight.

PROF. LUDINGTON: What asphyxiated them--gas? Lack of oxygen?

PROF. BELL: Probably the presence of gas.

DR. TAIGANIDES: That happened just outside Ames, Iowa. We ran an analysis on it. The man didn't feel there was any methane production that killed the animals, but rather it was the concentration of CO_2 that probably prevented oxygen from reaching the hogs. Since there was no fresh air, the hogs used up the oxygen and the CO_2 asphyxiated them. This is theoretical, of course.

Iowa State has a Public Health Service grant to do work in this field. This is an enormous problem, and it cannot be solved by the farmer himself. You don't have $45 per capita to build a sewage treatment plant. Here you have one man in a population equivalent to about 30,000 people, and he has to handle the problem. He can't put $45 per population equivalent into it because he can't afford it. We hope that some sanitary engineer tackles this problem and helps to find a solution.

PROF. CURRY: A cooperative project on farm waste disposal is now being conducted by the North Central group of Agricultural Experiment Stations. I believe that we should think about these solid wastes not as industrial, municipal, and agricultural wastes, but as being inorganic wastes and organic wastes. We should not be concerned particularly about where they come from. Possibly the solutions to some of the problems are the same for municipal wastes as they are for agricultural wastes, but they would apply more closely to organic wastes. Perhaps the term "biological wastes" would be a better one.

MR. PROCTOR: In Pullman, Washington we have a man with 7,000 to 10,000 white rats. He also has a problem. He sits right in the middle of a residential area that just finished prohibiting the production of a nice industrial plant, and his neighbors now don't appreciate him very much.

PROF. LUDINGTON: Why don't they appreciate him?

MR. PROCTOR: He stinks.

PROF. LUDINGTON: From a ventilation standpoint?

MR. PROCTOR: No. On his own he constructed an anaerobic lagoon to handle his wastes, right in the middle of a residential area. An electronics firm wanted to build a little plant across the street and he was the leader of the group that blocked the construction of that plant. He doesn't have much sympathy from his neighbors now.

PROF. LUDINGTON: Mr. Bell, what kind of lagoons are you working with now?

PROF. BELL: Both anaerobic and aerobic. The county agent comes to the Agricultural Engineering Department and they think he should have the answer. Some answers have to be gotten about the operation of a lagoon.

PROF. LUDINGTON: We have a lagoon just starting in operation. A poultry man has 320,000 chickens. He dug out about 6 acres of lagoon in a low, swampy area. According to his calculations it would last him four or five years. He wasn't sure what he was going to do after that, but that was four or five years away. As of about two months ago it was full and running over. I believe that this illustrates how people have lost all comprehension of the tremendous amounts of manure that are being produced, and because of this we are getting into trouble.

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Industrial Solid Wastes
The Problems of the Food Industry

Walter A. Mercer
Assistant Director
National Canners Association
Berkeley, California

If a nuclear holocaust and mass destruction of the World's population is avoided -- then the die is cast. The population growth rate of the nations will continue its accelerating upward spiral. Follows then -- the inevitable obligation to increase production of ever-better, more nutritious foods to sustain the good health and well-being of these multiplying masses of people.

Even now, the net rate of increase in human lives is more than one hundred thousand people per day. How unfortunate, that today, roughly half the population of the earth is undernourished from birth to death. Foreboding, but true, that in areas where population pressures are most explosive, food production is limited or uncertain. The moral burden of this nation then, must be to feed the hungry peoples of the world for many years to come. At the same time, plans must be made to meet the growing, more sophisticated food demands of our own people.

Since food growing and food processing invariably produces and accumulates waste materials, it is pertinent to the purposes of this Conference to attempt, first, to foresee what changes the future will bring in the food industry, and then, to outline in considerable detail the problems which are already looming in the present; and last, to suggest some possible approaches to solution of these problems.

A Quick Look Into The Future

Farms of the future will tend toward large, well-managed, and mechanized business paralleling the trends already evident in other industries. Surrounding the land, designated by law for agricultural use, will be highly urbanized areas beginning abruptly where the farm land ends.

Methods of growing foods are even now undergoing a drastic change spurred on by the needs of our economic environment. People are no longer willing or able to perform, efficiently, the laborious tasks in the production of foods. These tasks must now be largely done by mechanical means. The economic demand of our times has handed the plant scientist and the food grower the responsibility of developing and growing varieties of plants that produce high yields of foods which can be mechanically harvested.

In the near future, harvesting of the raw foods will be combined with some of the pre-processing operations which now are done in centralized plants. For example, tomatoes are still largely harvested by hand, stored in boxes in the field, finally loaded on trucks, and hauled to canneries. There they are washed to remove soil and other debris, sorted to remove inedible and poor quality fruits, and then processed into the desired final product.

Soon, machines will pick all the tomatoes. While still in the field, the tomatoes will be washed, sorted, and only the clean, edible fruit will be sent on the costly journey to the processing plant. Transportation by truck may be replaced by pumping of the comminuted product through sanitary pipelines ending at the point where final processing begins.

The final form of the food, the size of the package, and the nature of the packaging material must take into account changes in the trend of consumer preference. A stroll through a supermarket or a thoughtful examination of the home kitchen will show the consumer's demand for ready-to-serve foods. Preparation of food must be fast and simple. Instant coffee, dried mashed potatoes, frozen dinners, powdered milk and juices, and one-step cake mixes are only forerunners in this amazing trend.

In the kitchen of the future, we can expect that automated meal preparation will be possible. On a prearranged schedule the food items desired for a meal will be accumulated from the home refrigerator, freezer, or storeroom. Meal-size packages of food will be cooked almost instantly as they move from storage to the dinner table. It is not out of reason to expect that one may "dial-a-meal" in the morning and have it ready to serve at a designated dinner hour.

In the future, the mass of home garbage will be greater in volume but different in its composition. Since the kitchen will no longer be equipped to prepare raw foods for cooking and each pre-packaged food will contain only the edible portions, the garbage will contain no food refuse such as bones, coffee grounds, vegetable leaves, and fruit peel. Instead, the garbage will be bulky with metal and paper containers, disposable clothing, rugs, curtains, and the many other synthetic materials from which "no deposit -- no return" items will be made. The food waste materials must remain in the field or at the processing plant.

It is evident, even now, that the future processing of fruits and vegetables will be in segregated, centralized areas and in plants equipped with push-button mechanization. Regardless of the degree of centralization and automation in food growing and processing, the amount of inedible solid refuse can change little in proportion to edible portions of the raw food. At the field and at the processing plant we can only expect greater accumulations of wastes whose proper disposal or utilization will demand the best efforts of engineers, bio-scientists, and all who are concerned with environmental health problems.

A Long Look At The Present

It is not necessary to look into the future to find reason for worry about food industry refuse problems. They are with us today. Close scrutiny will recognize the first wave of a turbulent flood of troubles soon to disturb the complacency of our thinking about solid waste disposal and related problems.

Fortunately for all concerned, we have a test area -- California, particularly along the Pacific Coast where the westward surge of people must end. There each traveler to the Golden West must find himself a place in the teeming cities or in the remainder of the fast-diminishing open space.

Each day 1500 new people are added to California's population -- enough to occupy a small town; one-half million per year -- almost enough to occupy today's San Francisco. By 1980, California's present population of 16 million will have increased by close to another 16 million -- enough to occupy the 13 major cities of California -- if they were vacant, with enough people left over to create a new San Francisco Bay Area -- if an uninhabited area could be found.

What does this fulminating, land-consuming urbanization mean to the farmers and food processors of this state and the nation? With every daily increase of 1500 people, 375 acres of farm land must be changed to sub-divisions, roads, public and private facilities and all the non-agricultural uses of land which accompany urbanization of once-rural areas.

Before 1980, two million acres of new agricultural land must be equipped for irrigation and farmed to produce the food needed by the newcomers to the state. At the same time three million acres of highly productive land now devoted almost completely to irrigated agriculture must be changed into city land.

For example, within the fertile Central Valley of California we can now see the battle line forming between grasping acquisition of the land for urban development and its retention for growing the foods we need. Last year the farmers of the Valley produced over 5 million tons of raw foods for commercial processing. From this tonnage, the canners in the area packed more than 87 million cases of food. This production represents 60 and 80 percent, respectively, of the vegetable and tree fruit products packed in the nation.

On first thought, such an amazing production of food pictures a land of abundance without need for worry about food. But that is true only for today. Tomorrow, food production rates must be increased but the same expanse of land will not be available. Our now highly intensified farming methods must be further intensified. Food production must be done on land surrounded by urbanized areas -- beset with all the troubles which develop in the areas of conflict between expanding urban population and food production activities -- increased land values, decreased land area for waste disposal, increased waste production, and greater public health and nuisance problems in closer proximity to the human environment.

Agriculture is by nature a producer of great amounts of waste materials. To produce the desired fruit, prodigious quantities of inedible plant tissue must be grown. The tonnage of stalks, stems, leaves, and cull fruits left in the field or orchard far exceeds the tonnage of crop hauled to the processor or to the fresh market. For example, picking tomatoes by hand leaves a considerable residue of fruit which is too ripe or otherwise not suitable for harvest. Still greater residues remain in the field when the crop is mechanically harvested. Because the machine destroys the plant, harvest must begin when the greatest percentage of the fruit is at optimum maturity. More than three times the tonnage of the fruit selected for processing, is left behind as green, over-ripe, and damaged fruit and as the plant residue.

Beneath the trees in the orchards are accumulated the fruit which drops as a natural process and that which falls in chemical thinning to control the yield of fruit. Added to this are the cull fruits which are discarded during the harvest. The total tonnages of all discarded fruits is a considerable portion compared to that which finds its way to the market as a fresh or processed food. And so it goes for all of the field and orchard grown crops.

Each year 700,000 to 800,000 tons of tree fruits are grown in California's Central Valley. Nearly all of this tonnage goes to canneries for processing. Between 12 and 14 percent of this raw tonnage becomes a waste material consisting of pits, peels, green fruit, and defective pieces not suitable for canning.

Of the 3,150,000 tons of tomatoes grown for processing, 7 to 10 percent of the tonnage must be handled as a waste product. The processing of other products results in smaller total amounts of wet refuse only because the raw tonnage is much smaller. All together, it is estimated that each year during the three to four months of canning, between 500,000 and 600,000 tons of wet wastes are produced and must be disposed of by some method.

To those not well acquainted with the situation, comes the thought that there must be ways of utilizing this material. Utilization as animal feed comes quickly to mind. Some small percentage of the tomato waste is now dehydrated for this purpose; but this is a diminishing use since pesticide residues have been shown to be concentrated in the skin of the tomatoes.

Fruit refuse is 80 to 90 percent water. Dehydration would be extremely costly even though a feasible method of pressing and drying the waste could be developed. Pesticide residues concentrated in the peel are, again, a problem. The production of alcohol from fruit wastes has been considered and is technically possible. Sporadic attempts have been made. A major economic disadvantage is the seasonal nature of cannery operations. Year-round operation of the distillery would be an economic necessity. Of further concern would be the final disposal of still slops from alcohol production.

Added to these problems are the economic and technical problems of collecting and transporting the refuse to centralized processing plants, the putresible nature of the material, and the magnitude of the volume produced in a relatively short time period. The capacity of the processing equipment required to handle the short-time, high-volume production would be out of reason on the basis of the year-round capacity needs.

Other methods of utilization have been considered and judged to be infeasible at this time. One hopeful venture in utilization of peach pits also suitable for olive pits and walnut shells, will be discussed within this paper. Because utilization of food waste solids is not economical and otherwise feasible at this time, the remaining alternative is disposal of the wastes in the most economical way which complies with present public health and other regulations.

Presently, much of the solid waste materials from the canning of fruits and vegetables are dumped or spread on land. Nuisance conditions created by this method of disposal are the cause of increasingly severe criticism from regulatory agencies and complaints from the public. The breeding of pests, flies and other insects of agricultural significance, in the accumulated refuse are reported to cause economic losses of yet undetermined seriousness. The pesticidal spray programs used in attempts to control the insect population are cause for worry regarding the increasing level of resistance of the insects to killing by pesticide.

Heightened regard for stream and ground water purity has given rise to justifiable doubts about land-fill disposal of these high-moisture solids. Because of the air pollution aspects and wet nature of the refuse, incineration can no longer be considered as means of disposal.

Therefore, an urgent need exists for aesthetically-acceptable, rapid, reliable, and economically-feasible methods for disposal or utilization of the wastes accumulated in the growing, harvesting, and processing of fruits and vegetables. It is an alarming fact that if open dumping or land-fill disposal were suddenly, categorically prohibited, no alternative methods having established reliability and feasibility are available.

Disposal Methods in Use and Under Study

Ocean disposal of ground fruit wastes from a community of canneries in the San Francisco Bay Area has been working satisfactorily. However, this method of disposal is limited to coastal areas. Because of the threat of maritime strikes and the excessive costs of the operation, it can only be considered as a temporary solution to the problem.

A survey of other possible methods of disposal for these wastes indicated that high-rate aerobic composting should be investigated. For the past three processing seasons the Research Laboratories of the National Canners Association have conducted a series of pilot experiments to establish some of the factors involved in composting fruit waste solids.

This work has been supported in part by a grant from the Division of Environmental Engineering and Food Protection of the Public Health Service. The Sanitary Engineering Research Laboratory of the University of California provided a composting site for early phases of the work.

It was realized from the beginning that to be successful and acceptable the compost process would have to be non-odorous and free from fly problems. Because of this, the aesthetic aspects of the operation have received considerable attention.

Because the high moisture concentration in the fruit and vegetable wastes must be reduced, the composting method under study requires the use of dry wastes for which methods of disposal or utilization are also needed. Dry materials such as tree bark, sawdust, wood chips, dry municipal garbage, and cereal grain refuse are needed to control the moisture content.

Furthermore, it is expected that the experimentation will show that the high-carbon, low-nitrogen nature of the fruit wastes will require the use of nitrogen-rich wastes such as poultry and animal manures and dried sewage sludge. Thus, development of satisfactory methods for composting fruit and vegetable wastes may utilize these other troublesome materials.

The first experiments in the compost trials used open-top wooden bins, arranged around a concrete slab. The capacity of each bin was approximately one cubic yard. Previous work has shown that a composting mass of this volume will give reliable information applicable to larger-scale operations. This preliminary work was done with peach waste solids obtained from a cannery. This consisted of whole fruit, peeled halves, fragments of fruit, and the pits. Experimental results showed that grinding the waste accelerated the compost process.

Since fruit tissue is 80 to 90 percent moisture a dry, absorbent material was added to reduce the moisture content to 60 to 65 percent. Of the dry materials tested in the experiments, rice hulls, sawdust, coffee grounds, and composted municipal garbage have performed satisfactorily.

Three determinations are used to follow the progress of the compost process. The process is considered to be complete when the temperature reaches its maximum elevation and begins to decline. An equivalent indicator is leveling off of the pH after a previous steady rise. The gradual reduction in moisture is a result of evaporation at the elevated temperature and losses due to surface exposure to sun and wind. The addition of lime prevented a lag period due to the inhibitory effect of fruit acids in the compost mixture. Addition of lime shortened the composting period by approximately 50 percent.

Two important findings came from the preliminary compost experiments. After completion of the process and air-drying of the compost, it could be recycled as the dry material needed for moisture control in new lots of wet wastes. Up to this point in the experimentation this recycling of finished compost has no apparent detrimental effect on the process in succeeding lots of compost. However, further study may show that recycling of the finished compost, as the moisture absorbent, will accumulate end-products of biological utilization of the fruit materials which are inhibitory to optimum microbial activity.

A further finding, considered important from the viewpoint of operational procedures, was the minimal increase in weight and volume of the same lot of recycled compost repeatedly receiving new lots of wet solids. This was expected since the initial weight of the fruit solids is largely moisture which is lost during the process. Microbial action produces carbon dioxide and water from the residual fruit sugars and acids.

Since the greatest need with regard to fruit and vegetable waste solids is a satisfactory method of disposal, the production of a compost having market value has not been given consideration in these studies. For this reason it is considered important that recycling of finished compost apparently does not alter its textural characteristics and makes little change in its volume and weight. This, of course, will not be the case when the wet solids to be composted contain considerable fibrous or other materials not quickly decomposed.

During this year, carefully controlled experiments have been carried out using the principles and techniques developed in the earlier studies. These larger-scale experiments formed the compost into windrows on an asphalt-paved area. Both rice hulls and coffee grounds were used as the dry materials. For mixing in fresh waste solids and for turning and aerating the windrows, the compost was picked up with a truck-mounted elevator, carried over the top of the truck, and redeposited in a windrow-former. Frequent determinations of temperature, pH, and moisture were made to follow the compost process and to indicate when addition of new waste could be made to each windrow.

Each addition of fruit solids caused a marked drop in pH and an increase in moisture content. Following these initial changes, a gradual increase in pH and temperature and decrease in moisture occurred over a period of three to five days. This cycle occurred after each addition of fresh waste. Using these procedures, 20,630 pounds of wet solids were added over a 24-day period to a windrow containing 16-1/2 cubic yards of rice hulls. These experiments will continue with other types of high-moisture waste materials and using dry wastes such as wood chips, tree bark, paper and similar materials.

With regard to fruit and vegetable refuse the results of these experiments are the basis for the belief that composting process is a feasible means of disposal which eliminates public health problems. The major remaining problems are concerned with the collection and handling of the raw wastes and the design of composting equipment.

It is expected that the growth of population and industry in some areas will soon limit the land space available for compost operations. In many situations it will be desirable for the waste producer, on his own premises, to convert waste solids into compost or other stabilized by-products. In view of this prospect, a second phase of the current experimentation is investigating the mechanics of continuous composting.

In California, between 600,000 and 700,000 tons of peaches are canned each year. More than 65 percent of this tonnage is processed in plants located around San Francisco Bay. From these operations come each year, 50,000 to 60,000 tons of pits removed from the peaches by automatic machinery.

In the past and to some extent today, the canners have used various ways to dispose of this waste product. Pits have been buried in earth fills, pulverized and flushed into the sewer, burned, and buried at sea. All of these methods were less than satisfactory due to inavailability of land, air pollution, water pollution, pest control problems, or a combination of these problems.

Now the canners have hope for a solution. They are jointly financing a utilization operation which grew from the idea that peach pits ought to be the perfect raw material for the manufacture of charcoal briquets. This year during the period of July 20 to September 20, 500 tons of pits per day were delivered to a charcoal plant located on 20 acres of land at the south end of San Francisco Bay.

Trucks from the canneries deliver the pits to one of two 20-ton receiving hoppers. Juice and free water is drained into a tank from which it is eventually removed by truck and disposed of in a fill and cover operation. From the hoppers the pits are moved by belt and screw conveyer into a blower which deposits the pits in the storage area. There a bulldozer moves the pits into final storage.

Because the pits are wet and covered by adhering fruit tissue, two nuisance problems are possible. The fruit tissue could provide a breeding place for flies and other pests. Decomposition of tissue could pervade the surrounding countryside with a strong odor of fermentation. Up to this time, these potential problems have not been overwhelming. Stockpiling the pits layer on top of layer produces two results -- decomposition in the newest layer creates high temperatures which prohibit insect breeding within the mass, and confining the surface area facilitates treatment with expensive odor-masking chemicals and insecticides.

Each day the entire mountain of pits is sprayed with a quick-kill insecticide to which is added a residual-type material. Every other week during the period when fresh pits are received the pile is sprayed with a deodorant carried in a light diesel fuel base. The oldest pits in storage are used first. Present operations are using pits received during the summer of 1961. Prior to entering the pre-dryers, the pits are screened to remove foreign material -- particularly soil which would become glass at the charring temperature of 1600°F.

During the charring process, a suction fan pulls hot air from the kiln, passes it through the pre-dryers and finally injects the air into the base of the stack. Volatiles given off during the controlled burning of the pits are thus destroyed in the scrubber section of the stack where temperatures reach 2000°F. There is no apparent emission of smoke or other particles to add to the growing smog problem in the San Francisco Bay Area.

On a continuous run basis, the charcoal plant can produce 35 tons of charcoal in 24 hours using 120 to 140 tons of peach pits. The charred material is aged in the open for a minimum of two weeks, then ground and transported into the briquet-forming operations. First, edible cornstarch and warm water are added to the char to give the mixture a cohesive property. The ingredients are blended into a thick, smooth mass which is then fed to the press which forms the pillow-shaped briquets. From the press the wet briquets go to the drying oven where the residence time on the moving conveyer is two hours and 45 minutes. During this period the moisture is reduced from 30 to 5 percent. The briquets are stored in two 60-ton hoppers; from which they are packaged in bags of varying weight up to 40 pounds.

Although the peaches and the pits travel widely separated paths from the cannery, they end up side by side in the supermarket. Sixty thousand tons of pits representing a potentially serious waste disposal problem are changed into a necessary part of out-door cooking now so much a way of life in the West.

Some Comments and Recommendations

This nation could not sustain its current and expected population without the modern-day food-producing and food-processing industries. The increased refinement and palatability of foods, convenience of their use, and relative low-cost to the consumer are remarkable benefits of modern agriculture and food technology. All of these benefits are expected -- even demanded -- by the food consuming public. An inevitable consequence of meeting this demand has been the production of larger and larger volumes of both solid and liquid wastes.

The food industries must recognize the need for close examination of their processes for the purpose of eliminating preventable food wastage. Without doubt, the food industries must also attempt to correctly evaluate their responsibilities in the prevention of problems arising from disposal of food wastes. There is ample evidence of a growing awareness of these industry responsibilities.

At the same time the food industries must point to the fact that much of the complexity and magnitude of food waste disposal problems are not of the industries' own making. Explosive invasions of people and urban industry into once wholly agricultural areas have aggravated and multiplied these problems.

Must the farmer or food processor bear the full economic burden of solving the waste problems created because he is suddenly engulfed by the outward surge of urban growth? Totally unprepared, he must now share water, disposal facilities, land, and even the fresh air around him, with invading industries and housing developments. New methods of waste treatment must be found; new and costly waste handling procedures must be designed and proved. Only community efforts can solve these problems.

Should the cost of these non-productive efforts fall to the food growers and processors, it cannot be added to the price of the food items in the market place. The housewife cannot be expected to reward the grower or processor who went the second mile in solving a waste problem, by paying a premium price for his food product.

Technical help, developed through research, is urgently needed. To this end, research programs designed to establish the technology and feasibility of community-wide, area-wide waste management must be undertaken. To implement these waste management efforts, surveys must be made to ascertain the types of wastes occurring in a given area, the volumes of these wastes, and the time of the year when each is most prevalent.

Long-range forecasting must attempt to predict what changes the future will bring in the occurrance, handling, and disposing of wastes. Such information has unlimited value to industries, such as food processing, in locating and designing future plants. Many future difficulties could be prevented if adequate information were available on which to plan waste treatment facilities for these operations.

Other research efforts must develop techniques and operating procedures for treating or utilizing each type of individual waste which is now or may later be the cause of environmental health or economic problems. Although, in many cases, the treatment and disposal of solid refuse may best be done in centralized operations, disposal at the point of origin should receive considerable attention. The collection and transportation of wet solids, such as that from food processing, is beset with serious problems which would be eliminated by on-site handling.

Industry, in most cases, must be given the design criteria and operational procedures for technologically feasible methods of solid refuse disposal. It cannot be expected that each producer of an industrial waste has the trained scientists needed to develop these methods. Furthermore, human nature and economics being as they are, food producers and processors can be expected to delay action on non-productive situations until an emergency arises. No satisfactory, economical method of solid waste disposal may be known when the emergency comes.

The canning industry believes that the Public Health Service through the Solid Wastes Engineering Section of the Division of Environmental Engineering and Food Protection is the proper agency for developing and disseminating the information so urgently needed. To this end the following recommendations are made:

1. All necessary support should be given, to the appropriate agency in the Public Health Service, for the development of technical and administrative staffs adequate in number and ability to meet the critical needs for action in solid waste disposal.

2. Central and regional research centers must be established for implementing a solid wastes engineering research program with location priority given to those areas judged to have the most urgent problems.

3. The scope and intensity of research on solid wastes disposal must be expanded through grants and contracts awarded to qualified institutions preferably located in areas where these problems are most acute.

4. Every effort should be made to enlist the technical assistance and good will of industries producing solid wastes and to support research in qualified laboratories of these industries.

5. When adequate information is available, an educational program should be designed to emphasize the health and economic aspects of improper disposal of solid wastes and should be directed to the citizen, his governmental representative, and the producers of solid wastes.

Finally, let it be said for the canning industry that it knows there are no simple solutions to the problems of solid waste disposal. Farmer, food processor, dairyman, manufacturer, housewife -- all must live together in a group, each dependent on the other. As relentless population growth and industrial development narrows the living space, each must relinquish more of his precious portion and share more with his neighbor.

GENERAL DISCUSSION

CHAIRMAN ROGUS: Thank you, Dr. Mercer.

To get the ball rolling, you say you represent the National Canners Association and yet you limited your discussion to the canning and processing of fruits and vegetables. Is it a fact that the National Canners Association covers the whole spectrum of the canning industry--fish, meats, and so on?

DR. MERCER: Yes, that is true. However, the problems associated with other products are not as acute as they are with regard to fruit and vegetable canning.

CHAIRMAN ROGUS: You said the National Canners Association represents a certain portion of the canning industry but not the total. I imagine you must have some ideas on what the total solid waste output is of the entire canning industry.

DR. MERCER: I don't have the figures here, but it certainly would be estimated. It might be an amazing tonnage. The percentages of waste material on a tonnage basis would be very similar to what we are talking about here.

MR. PROCTOR: You gave us a figure of 500,000 to 600,000 tons of wet refuse a year. Was this confined to California fruit and vegetables?

DR. MERCER: Yes--one central valley of California.

PROF. LOEHR: You have developed the theme of processing of fruit and vegetable wastes. I got the impression that this is the waste originated at the processing plants. How are the wastes left in the fields handled?

DR. MERCER: Presently they are left to lie in the fields. This has been the cause of some rather serious problems. Fly production, for example. The wastes are eventually plowed into the ground, of course, but even here there is a potential problem which I would like to develop at this moment, namely, the fact that the plowing in of organic material of this type accumulates and multiplies the numbers of heat-resistant therophilic-type organisms in the soil. In the Delta region of the Sacramento River there is a considerable expanse of peat soil which has been developed over the ages from the bedding down of marsh grasses, and this has undergone heat and fermentation. The crops which are grown on these soils give us considerable trouble because it is impossible to remove all of the heat-resistant spoilage-type organisms which are present on the raw product that comes from these soils. I am wondering what the addition of compost would do to soils if it were carried out over a number of years, for example.

CHAIRMAN ROGUS: Hasn't it been demonstrated that in normal composting, not necessarily even getting into the thermophilic range, you get a pretty complete or nearly complete destruction of the pathogens?

DR. MERCER: Yes, I think you do of the pathogens; but I am speaking here of heat-resistant organisms which are not killed in the sterilization process that canned foods undergo, for example. There is no harm except that it is an economic problem. There is no public health hazard involved, but rather a shorter shelf life.

PROF. MORRISON: May I take extreme exception to your statements regarding the responsibility of how to dispose of this waste--how to abate the nuisance of this waste accumulation.

Could not the canning industry afford to develop its own technical staff and its own technical research, passing the cost on to the consumer? It will be far cheaper to add 0.2 cent to the price of a can of peaches than it would be to expect governmental agencies to provide the research, laboratories and personnel to take care of this problem.

I think we need a cooperative effort between government, industry, and academic institutions at the state level, but I can't see that this is a responsibility of Washington, which is using my money, to worry about California's waste problem. The canning industry is making a profit operating in California. I don't see the feasibility of using government money to solve the waste problem.

CHAIRMAN ROGUS: I think it can be said that it is one of the basic policies in this country that industry generally is left to clean its own house--either individually or by cooperative effort. It would be my thought, too, that the canning industry, which of course is very large, should pursue an approach similar to what other industries have been doing, for example, in the matter of sewage treatment? The chemical industries and paper pulp industries have had to solve their own problems and treat their liquid wastes in such a way that they could be discharged into public streams without creating a nuisance.

DR. MERCER: Perhaps I have created the wrong impression. I did not intend to indicate that we expect the government to subsidize the cost of disposal. What I intended to say was that we would like to be told how to solve these problems. We would appreciate it if the government or other people who are doing research would tell us how to solve these problems.

PROF. MORRISON: I think you have made a statement that is doomed to failure, because in any case where the government has come in and has told an industry how to do it, the immediate attitude of the industry is to get up on their hind legs and tell the government where to get off. Industry will be far more prone to adopt a method or procedure which is their own, and not a procedure that is handed to them as an edict from a control agency.

PROF. BRUCE CURRY: What percentage of gross product cost to the canning industry is put into supportive research in various areas of solid waste?

DR. MERCER: The members of the Association spend around $100,000 a year or more on waste problems. The whole research budget is in the area of $500,000 or $600,000 a year.

PROF. CURRY: How much is known about the composition of the various products that have to be disposed of? Is this pretty well known? Do you know what you are working with in terms of chemical characteristics?

DR. MERCER: Yes. We have some publications which characterize this waste in some of the terms Mr. Bell talked about this morning--hydrogen, and so on.

CHAIRMAN ROGUS: Do you think the canning industry has pretty definite and precise figures on the total amounts of solid waste?

DR. MERCER: We don't have enough information on the amounts of solid waste, but we know pretty precisely what the nature of these wastes is.

MR. KAISER: If you had some control of this heat-resistant organism that you say is in the soil, then you could put all this waste back and plow it under; right?

DR. MERCER: That is correct. The trend, of course, is to reduce processing temperatures and times in order to come out with a better product.

MR. KAISER: You could kill the organisms by using higher temperatures.

CHAIRMAN ROGUS: This morning, you will remember, the statement was made that the amounts of solid waste produced by the agricultural industry are so vast that it seems to be rather difficult to absorb them by returning them continuously to the soil; at least that was my understanding of the discussion. In the face of that, would the canning industry be in a different position? Could they actually absorb and replenish their soils with this composted material if they were able to compost it?

DR. MERCER: No. I don't think they would be in that sense. I think the canning industry would like to be independent from the growers.

MR. KAISER: In the case of peas, they used to cut the pea vines and take them to a viner; the peas would come out and the farmer would take back his pea vines and either make a pile of them or put them in a silo for feed; or, if he wanted to, he could put them right back into the soil and plow the vines under, and in that way get rid of them.

PROF. MORRISON: Isn't it more of a problem than just the canning of the product and the carry over of thermophilic thermodurics? Isn't there also a fear of adding back peach viruses? Fruits have viruses which are not killed in the normal washing and peeling process. Orchard raisers may not want to take back wastes from plants grown elsewhere.

DR. MERCER: Correct. You can add to this the solid refuse, in which pesticide residues are concentrated. Putting this material back into the soil may cause accumulations in the soil which can be assimilated by raw foods grown on that soil in subsequent years. A good research problem for someone would be to determine the fate of pesticide residues in the soil, or in composting, for that matter.

PROF. MORRISON: In composting have you noticed the effect of streptomycin sprays and actidione sprays that are being used at the present time?

DR. MERCER: We have not investigated this, but it is a good research problem for someone.

PROF. BELL: Forgive me for going back to a topic we have already discussed. On this $500,000 to $600,000 research budget, who is it that actually conducts this research? Is it conducted by the industry itself, or do you contract with consulting firms and universities?

DR. MERCER: The research is done in our own laboratories, which are a part of the Division of the Association.

PROF. BELL: Would it be possible for a university to contract with you to conduct such research?

DR. MERCER: That is possible in some areas. We do make grants-in-aid to some universities for work on a particular problem which we feel is out of our line.

PROF. CURRY: I would say that, per acre, the amount of waste from fruits and vegetables is not nearly in the same magnitude per acre of available land as the waste from animals.

DR. TAIGANIDES: I don't have any figures, but I believe the amount of fruit wastes--peelings, leave droppings, etc.--would be tremendous per acre of land.

PROF. BRUCE HANES: Regarding pesticides the concentrations on the peel are due to the residuals left from spraying. Are they not building up pesticide residuals then in the soil? I would imagine the plants that are left there have the same residuals on them, and also some of this would be entering into the soil directly.

DR. MERCER: The type of pesticide I am talking about is not assimilated by the plant tissue except in the case of tomatoes. When it is deposited on the surface of the tomatoes it works its way into the skin of the tomato and does not go any farther than that. If you remove the peel then you have a product that has no pesticide residue in it, but it is highly concentrated in the peel. In fact, we use tomato peel as a source material for pesticide residues, which have been applied commercially, in our research on the development of analytical methods for pesticide residues in foods.

PROF. HANES: Do you find this residual in the leaf of the plant?

DR. MERCER: Not in the leaf; just in the oil of the tomato skin.

PROF. MORRISON: The American economy calls for and will pay for a well pealed pear or peach. With our assumed responsibility for feeding big areas of the world, what is the possibility of using this inferior quality (by our standards) nutritionally valuable food, drying it and pulping it and making a food product that can be used elsewhere in the world where people are starving?

DR. MERCER: This thought deserves much consideration. It has come up before, of course. The problem is what sort of public relations we would create in the world if it became known that we were shipping garbage to the rest of the world. The communists would make real hay out of it.

PROF. BELL: I think the problem is that we now have a surplus of good food that we do not send to foreign countries. We have stockpiled good food and yet aren't sending it.

CHAIRMAN ROGUS: That is something that has always confused me. We hear and read that we should embark on some sort of vast conservation program to retain the fertility of our soils because we are depleting them, and yet we are faced with a surplus of foods that we are literally wasting. But I believe you said the problem is one of temporary character, and eventually we will be faced not with surpluses but with shortages.

PROF. MORRISON: I have heard it said that by the year 2000, if you project our population and the land mass used for highways and urban development, we will be short of food.

CHAIRMAN ROGUS: In other words, we will not only decrease the fertility of our soils but we will actually decrease the acreage of those soils, and the population of course will demand much more in the way of food.

PROF. CURRY: It is also true that one or two years of some sort of climatic disaster would eliminate all our surpluses in short order.

PROF. AGARDY: If we are going to worry about land availability for agriculture, why not cart some of this material into arid regions and begin building up a source of organic matter in the soils that are ultimately going to have to be irrigated and used by agriculture?

DR. MERCER: Who is going to bear the cost of transporting this material?

MR. WASSON: I think you come right back to the law of supply and demand. When the supply doesn't meet the demand, then people will pay for the services necessary to carry on advanced work.

CHAIRMAN ROGUS: We are beginning to be plagued by this competitive aspect more and more. The canners are willing to get rid of their end products provided they are told how to do it. Some objective agency, probably a governmental agency, with all of the facilities at hand should make it their responsibility to develop this know-how because this is of nation-wide interest.

DR. MERCER: Yes. We would be willing to cooperate to the fullest extent, and we are doing that now, but we are not going fast enough.

MR. PROCTOR: The canners would be willing to find out the methods of solid waste disposal provided they could avoid jeopardizing their own competitive position in so doing. Each one would be willing to work on his own methods if, let us say, in so doing the California peach producers weren't wiped out by other people in the country who can produce peaches without such efforts.

PROF. MORRISON: The American consumer deserves to get a cheaper product from Florida or any other place if that area can produce at a lower cost. But most of the canners are not local people. The real mass producers have tomato plants in California, Indiana, Florida and Virginia. They are in competition. If bananas are high, the consumer will buy peaches.

PROF. BELL: What is the pressure presently put on the canning manufacturers by regulatory agencies as far as waste disposal is concerned? This is the reason why other industries--metal, chemical, and so on--are getting consulting firms, research institutions and universities to study the problem. I was wondering if in the near future the canners will be forced to do something about their own problem.

DR. MERCER: The pressure has been considerable, and the canners have been working on the problem for sometime. We have had a Department of Research on waste disposal for 35 years in our research laboratories; but, as I tried to point out, this is not a problem that can be solved by the canning industry alone. The canning industry cannot solve its problems without taking in the help or at least soliciting help from other people who are in the same area. This has to be a community effort--an area-wide effort.

CHAIRMAN ROGUS: Addressing ourselves to a slightly different aspect of this situation, is there any noticeable trend in the canning industry to get away from the present types of metal containers, whether they are of steel or aluminum or what-have-you, and into some type of synthetic containers?

DR. MERCER: Yes. The can manufacturers are experimenting with different types of substitutes for metal containers. The can today, in most cases, costs more than the product in the can. We would like to use plastics, for example. Thermostable plastics are being considered. Some concentrates are being packaged in metal foil. This is probably the first step in that direction.

CHAIRMAN ROGUS: In other words, you think that in the foreseeable future it is quite possible that our refuse, instead of having such a very high tin can content, may conceivably be replaced by something which may or may not be burnable, and may or may not be compostable?

DR. MERCER: Yes. The metal can is giving us considerable trouble. The metal is so thin that we are having all sorts of corrosion problems. The shelf life of the product is considerably shortened because of the nature of the can produced today.

CHAIRMAN ROGUS: Could you tell us briefly just what type of materials are being contemplated?

DR. MERCER: Plastics come first; then, for some types of products, a liner of some sort. A prefabricated or composition type material, is a possibility. Speaking of concentrates, almost any kind of container will keep them for a considerable period of time. Many California packers put fruit and tomato concentrates in 50-gallon drums, for example, and the only requirement is that the drum must withstand a sterilization temperature that would kill any type of organism in the concentrate. Up to this point the temperature would have to be around boiling. If the material will withstand this temperature, and will withstand shipment, it can be used.

PROF. MORRISON: The frozen juice industry is already packaging in thin aluminum cans. Also, much of the glass from the food and related industries--cosmetics, drugs, soap products, liquid soap products, and so on--is disappearing. I think we are going to see greater use of high-compression plastic.

PROF. KAISER: There is one precaution when it comes to incineration of these containers. They should not be teflon chlorinated plastics. The flourine is apt to give a terrific air pollution problem. Polyethylene or something of that sort is a good fuel and can be burned up. All tin can isn't too bad in an incinerator.

MR. PROCTOR: There would be some interest on the part of the conservationists in the trend from the tin can to the aluminum-topped can, and the beer bottle that now no one has any incentive to return. We find the beaches, highways and rivers littered with these things.

PROF. HANES: What percentage of the budget of the American Canners Association is committed to waste problems?

DR. MERCER: About one-fourth. Water conservation, liquid and solid waste, is now our most critical problem.

PROF. HANES: Do you fell that the canning industry will ever really solve this problem before it is told that it must solve it within, say, a five-year period or something like that?

DR. MERCER: We are working hard on the treatment of liquid and solid waste, but I am fearful that we aren't going to be able to find feasible solutions quickly enough.

PROF. HANES: I recognize your problem, and I realize that ultimately we have to pay for it as individuals. The question is how we are going to pay for it. Are we going to pay for it by increased product costs or by increased taxes?

DR. MERCER: Well, the canning industry now pays on the average about 0.7 cent per case for waste disposal, and we foresee in the not too distant future that this may go up to 4 to 5 cents per case; and of course this will have to be passed on to the consumer.

PROF. HANES: If you can do this uniformly throughout the country so that you are not put into a disadvantageous competitive position, what does this do to you on the world market--or is this a concern?

DR. MERCER: We have a very peculiar system in this country. Our laboratories are a mecca for food technologists from all over the world. We continually have groups of people from various countries who are interested in copying the canned food production methods of this country, and the time is not too far distant when we are going to have considerable competition in the world market.

PROF. LOEHR: If I remember correctly, you quoted a figure of something like $100,000 being spent on waste disposal. You said this is a quarter of your budget, but $100,000 is very small compared to the amount of money being spent and the amount of profit obtained from this business. There are many organizations which plow back 2, 3, 4 or 5 percent of their profits into research.

DR. MERCER: The research I am talking about is only one facet of the whole activity of the National Canners Association. There are many other things. The research laboratories are only one division. We have economics, fishery products, and various other divisions which use money also.

PROF. RICHARD BOUBEL: I was interested in your ocean disposal of waste. How far out at sea was this, and have you ever used any pipeline disposal at sea?

DR. MERCER: In the operation that you saw, the water pollution control people, the fish and game people, and various other agencies that are concerned with maintaining the purity of the Pacific Ocean decided it should go 26 miles out beyond the Golden Gate. The operation of the barge--that is, the speed of the barge, the rate of discharge--was all prescribed. Our laboratory carried out the program as required by the water pollution control cpeple, and we could not see that this discharge was having any effect on the Pacific Ocean. But there has been one attempt to discharge from a pipeline into San Francisco Bay, and this created considerable problems. It had to be discontinued.

PROF. HANES: In building a new canning plant, does your industry consider waste disposal as part of its original economic study?

DR. MERCER: Yes; and there were plans made several years ago that have not been carried out simply because there was no enforcement. For example, we have five canneries in Stockton, California. They process the agricultural materials that are grown within a wide area around the city, and employ a great number of people. But the population equivalent--that is, the amount of waste discharged by the canneries during the canning season--increases the population of that city to about 800,000 when normally it is about 20,000.

CHAIRMAN ROGUS: Gentlemen, it is time to adjourn. We certainly want to thank Dr. Mercer for his very excellent presentation and for his patience during all of this cross examination.

DR. MERCER: May I say just one more thing. It disturbs me that the National Canners Association has a longstanding policy not to sponsor or suggest any measure that will increase the national budget by any amount. So, I am not advocating anything that would cost the taxpayer more money. We have numerous publications about this and other problems; if you are interested, write me a letter.

PROF. BELL: You mentioned "laboratories" several times. How many laboratories do you have?

DR. MERCER: Three--Seattle, Washington, and Berkeley, California.

CHAIRMAN ROGUS: Thank you very much, gentlemen.

Concurrent Panel Session

Waste Collection, Storage and Transportation

Group B

Waste Collection, Storage and Transportation

William A. Xanten
Superintendent of Sanitation
Washington, D. C.

At the outset of any broad discussion of this subject it would be well to outline some axiomatic factors which have served to influence the practices in this field and which tend to justify the variety of systems now in use. Also, it is well to keep in mind that while a great proportion of the solid wastes of a community are produced as refuse incident to the ordinary conduct of a household (including yard refuse), that commercial and industrial waste in most urban centers of population, as well as debris from construction and razed buildings, street sweepings, abandoned automobiles, large tree stumps and logs, dead animals, and the like, constitute enormous and special problems that cannot be ignored in the overall picture.

In order to maintain an orderly approach to the consideration of these matters it is therefore suggested that we hold ourselves as nearly as practicable, to two broad categories of solid wastes: (a) refuse incident to the ordinary conduct of a household (including yard refuse) and (b) all other special categories including commercial and industrial wastes, etc.

The Conference Chairman has expressed the desire that we concentrate on ideas that will stimulate some badly needed research in this field, without dwelling too much on the magnitude of the problem. There has been a wealth of written material, both foreign and domestic, on the general subject, including the exhaustive treatises published by the American Public Works Association in recent years, so that if we have done our homework most of us should be aware of existing practice. Unfortunately, and I say this with deference to those (if there are any) who think they have all the answers, the more one reads up on this particular phase of essential public service the more confused he becomes with the lack of uniformity and the infinite variety of systems in effect even in communities where the local conditions are quite comparable. This is not to say that "local conditions" are not a prime factor in arriving at sound and economical solutions but I have long felt that in too many instances the phrase has been abused, and used to justify practices that are not conducive to proper results. Particularly with respect to Category (a) - household wastes, it would seem that there should be some attempt by researchers to sort the thing out so that such basic items as frequency of service, point of collection, size of crew, separation and storage requirements, types of equipment, haul factors, and the like, can be related, evaluated, and graded in such a manner that communities would have some idea of what they are getting for their money or to enable them to reasonably determine what they are willing to pay for. Perhaps this is hopelessly complicated because of the infinite number of variables, but it might be possible to simplify the approach by deliberately disregarding some of the more grotesque practices now in effect. It might also serve to highlight some practices which have been clung to over the years for perfectly good reasons of economy, but which should not be considered acceptable from a public health standpoint.

An admirable approach along these lines was made by the University of California Sanitary Engineering Research Project in 1952, which is carried as Appendix D in the APWA treatise on Refuse Collection Practice, but unfortunately the scope was confined and influenced by data from thirteen California cities only.

It is interesting to note some of the more profound and significant statements made in the APWA treatise, and I quote:

From Chapter 1

> The Refuse Collection Problem -- ". . . Not that methods, equipment and practices should be uniform over the country. Conditions vary, and it is vital that procedures vary to meet them. However, the problem should be approached the same way in all communities, should be analysed in terms of sound administrative management, and should receive the same consideration usually given other public health aspects of government."

Standard of Service -- "There is no general measure yet available that can be used to judge the effectiveness of a particular collection system."

Effect of Disposal Methods -- "The means used to dispose of refuse influence collection practices to such a great extent that the disposal methods must be determined and the disposal sites selected before the collection system can be intelligently studied."

Organization -- "In practice, refuse collection organizations are arranged by American Cities in every possible way -- and this cannot in itself be condemned, for the benefits and disadvantages of each plan must be considered in the light of the local circumstances."

From Chapter 3

Preparation of Refuse Collection -- ". . . The task of the public official is to achieve a reasonable balance between public convenience and satisfaction on the one hand and the essential requirements for public sanitation, for municipal cleanliness, and for economical collection and disposal on the other.

From Chapter 4

Factors Affecting Cost -- ". . . Conditions and practices in the field of refuse collection vary so much from place to place that it can be truly said that no two cities present exactly the same situation . . . sometimes the convenience of the householder is subordinated to economy of operation."

From Chapter 7

Planning Refuse Collection Systems -- "It should be repeated that there is no acceptable substitute for careful factual analysis."

No one who knows what is going on can quarrel with these statements. They factually represent the existing situation in the United States, and for that matter can be applied to other countries throughout the World. But surely these widely accepted facts are one of the fundamental justifications for this Conference, and whether we like it or not I suspect that the complexity of the subject will make it quite difficult to pinpoint areas for research. Nevertheless, this is the task we have set for ourselves and I can only hope that we bear in mind in our subsequent discussions the need for isolating some of the parts of the overall problem without spending too much time on the acknowledged difficulties inherent in the generalized approach.

Because of the differences in methods of approach, nomenclature, record keeping, cost accounting, and a number of other variables, cost comparisons between cities is not only difficult, but can be dangerously misleading unless carefully interpreted. The effects of domestic incinerators and back yard and site burning on the volume of combustible refuse to be handled can be enormous. Would it not be worthwhile to select a half dozen typical American cities for an exhaustive study of the actual types and quantities of refuse being generated, so that more meaningful per capita figures can be established, segregated into perhaps the three broad categories of "household", "commercial" and "industrial".

Great strides have been made in the areas of improved collection equipment, containerization, and the design and operation of transfer and marine loading stations. The introduction of frozen foods and garbage grinders has had a substantial effect in some areas on the quality of the remaining refuse to be dealt with. Gas and oil have had their effect on ashes and cinders. Rubbish and yard refuse continues to increase by leaps and bounds, with air pollution controls having a marked effect on the overall problem, particularly in the larger communities. Nevertheless, nondescript receptacles are all too prevalent in American cities; nor do we have much precise information regarding the cost of "point of collection" in terms of labor requirements. Many cities that incinerate refuse permit metal and glass (and sometimes ashes) to be mixed with combustible refuse in order to avoid separate collections for these items, and perhaps for other reasons. Is this good or bad practice, and does the "local condition" entirely justify this approach? Why can't we have more rugged truck scales that can stand the impact of hundreds of heavy duty vehicles daily without so quickly losing their accuracy?

There must be certain "breaking points" on ton-mile costs as related to fleet operations. Can they be established in general for relatively large increments of a fleet in such manner as to establish some guide lines for justifying the provision of additional shorter-haul disposal facilities for collection units? It is worth noting that one common method of dealing with long hauls has been the tendency to reduce the number of laborers/crew to almost zero - by requiring the driver to both drive and collect - but this, of course, requires sacrificing the full utilization potential of expensive truck equipment. A variation of this method is the utilization of "swing" trucks, particularly in the case of set-out, and set-back systems where haul is an important factor.

These and a number of other items are indicative of the type of discussions that might lead to justifiable projects in terms of study and research.

There can be little disagreement that one of the slowest, costliest and least desirable methods of collecting refuse is to permit householders to dump it in piles for shoveling-up by labor. A less costly and more sanitary method is to require it to be put in regulation receptacles for emptying into collection units. But what about the possibilities inherent in the faster, quieter, and cleaner method of taking a relatively cheap disposable receptacle such as a paper bag along with the refuse, a system now finding favor in European practice, and one even now being adopted in some smaller communities in the United States.

It is apparent that this system has natural advantages from a litter-control standpoint on landfills, and should have a marked effect on dust problems at incinerator plants. Here is a progressive development which surely deserves both careful research and trial because of its overall benefits, even though in some cases it may appear to have higher first-cost implications.

There can be no doubt that as a community increases in size and complexity that the solid waste problems mount in a geometrical rather than an arithmetical progression. Such elements as length of haul, requirements for more expensive disposal mechanisms to maintain high-level and nuisance-free sanitary controls, dense traffic patterns, higher service frequencies, etc. all tend to emphasize the need for adequate administration and management and careful long-range planning.

Recent reports of solid waste studies for the Northeastern Illinois Metropolitan Area and Metropolitan Dade County are indicative of the scope of the problem in such densely populated areas. Both reports are replete with references to the acuteness of the problem both now and in the future, particularly with reference to disposal. In the Dade County report a quote of more than passing interest:

> "Following the County Manager's notice to stop open burning in February 1962, the fill rate increased to 213% of the rate for 1961."

This is not, of course, to be interpreted to mean that the refuse increased to this extent, but rather that the combination of additional quantities plus the elimination of previous dump burning practices in favor of sanitary landfilling had a serious effect on the lift of their fills.

For those considering careers in this field, and tackling the problems of large cities from an administrative and engineering standpoint, it can be predicted that they will find formidable but rewarding challenges. And let it be said that the range of their duties will include very complex personnel and public relations aspects, as well as pioneering work in a surprising number of knotty engineering and scientific subjects. And speaking from experience, this is no field for drones.

There have been many controversies and a modicum of hypothetical nonsense applied to the subject of combined refuse collection. There are those who advocate this approach on the grounds that it is by all means the cheapest because of the avoidance of multiple coverage by different crews. There is, of course, a fundamental truth to the concept that once around is better than twice around for the same purpose. But there are a host of legitimate reasons why segregated collections in some cases may be the best and most economical approach, and in fact most communities are governed to a large extent in their solutions to this phase of the problem by (a) their disposal practices; (b) collection frequency considerations; (c) salvage value of isolated items, or service limitations for special types of refuse, such as, yard refuse, refrigerators and the like.

While the subject of refuse disposal is being dealt with by another group at this meeting, it is difficult to refrain from suggesting that Group B anticipates hearing that a research project has been recommended to establish the intrinsic value of compost in the United States, with some practical approach perhaps in collaboration with the Department of Agriculture to the marketing potentials as well as the use potentials of the product for either direct application to soil or as a base for fortification as fertilizer. Surely there is enough refuse produced in this country to provide an ample sufficiency of both, and it is time the subject was met head-on!

These comments have so far been largely confined to Category (a) - Household Wastes. The great variety and complexity of the special problems involved in Category (b) - Commercial and Industrial Solid Wastes, make it virtually impossible to deal with the subject in the time allotted. Furthermore, this is an area where the "buck" is passed along in many instances to private initiative and private collectors, and where the problems of disposal are the more acute. Containerization has, of course, been a useful tool, and we will get into this subject in one of Group meetings. One cannot help but feel, however, that there must be room for much research to arrive at solutions to some of the special problems in this phase of solid waste collection and disposal.

Group B is scheduled to discuss a number of facets of the overall problem at subsequent sessions. It is my hope that at these sessions we can stick to the subject matter and avoid undue overlapping. I suppose its also fair to say that the group discussing disposal practices will hear our loud cries in the collection end for help in considering shorter hauls to disposal sites. Nor do we want too much argument about improved storage practices that might further complicate problems of disposal. But there are a number of areas where applied and basic research can be helpful.

Systems Analysis for Solid Waste Problems*

Walter R. Lynn, Ph.D.
Associate Professor of Sanitary Engineering
Cornell University
Ithaca, New York

The purpose of the National Solid Waste Research Conference is to stimulate research in solid wastes ". . . (by suggesting) new ideas and approaches and (thereby) attracting new researchers to this area." The function of this paper is to indicate how "systems analysis" has contributed to this purpose and what contributions may be made by such analyses in the future. The outgrowth of systems analysis (or operations research) as an area of research interest is generally associated with the development of techniques for analysis of military logistics and strategy problems during World War II. The continued interest in these classes of problems has resulted in considerable research covering a wide variety of general and special problems in many fields. Because of the scope of these developments it is impossible to condense these many activities into a few descriptive and meaningful sentences. However, in order to satisfy the requirements for this presentation it will be necessary to discuss some aspects of what it is that systems analysis is, does and can do.

Unfortunately the term systems analysis can be misleading because it gives one little insight into what practitioners of the art are doing or for that matter what they would want to do. What is a system? A system can be defined as a collection of interacting components which function in a prescribed manner and thereby achieve a certain result. The components of any system (for example: physical, chemical, or biological entities, machines or parts of machines, materials, men, pressure, etc.) can be defined as sub-systems since they themselves may function as systems. The point being that systems can be studied at various levels depending upon the purpose of the investigation. Coupling this (operational) definition of a system with analysis we obtain the notion that systems analysis deals with understanding and evaluating the interactions of system components. Implicit in this approach is the concept that the analysis is undertaken to satisfy particular objectives and to quantitatively evaluate how the components affect these objectives. The most commonly used objective is an economic one for which one might ask, "how can the system be operated to incur a minimum cost?" Another way of stating this objective is "how shall we allocate the use of the components which compose the system such that the system cost will be minimized?"

It should be noted that the question asked is not traditional inasmuch as we require that the answers resulting from the analysis include operational information. In the traditional approach one makes a priori allocations to the components and then evaluates their economic consequences. Finally these trial allocations and their economic consequences are compared and a selection (of a minimum or maximum) is made from among them. Obviously, since the allocations are made independently of any economic criterion one could only expect to obtain a minimum cost by being exceedingly lucky.

In general the techniques of systems analysis deal with problems in which it is desired to maximize or minimize some objective which is subject to a set of requirements or constraints. The analytical methods are primarily mathematical and solutions frequently require the use of electronic computation equipment. The mathematical methods used for systems analysis are usually catagorized as being in the area of "mathematical programming."

A simple example can be used to clarify the concepts of objectives and constraints. Let us presume that a community is confronted with a solid waste disposal situation and it is necessary to decide which method or methods of disposal should be used. We will assume that the volume and character of the waste materials collected from the community are known. Examination of existing technology of waste disposal indicates that the following methods of disposal are

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* *This work is supported in part by a USPHS Training Grant (1T1-WP-42-01).*

available for use in this situation: 1) incineration 2) composting 3) grinding and discharge to sewers 4) ocean disposal and 5) sanitary landfill.

The question we pose will be, ". . . how should we allocate the total volume of waste to be treated to the various methods such that this allocation will result in a minimum cost?" Thus our objective is to minimize total cost. In order to mathematically describe this objective (and thereby obtain an objective function) we need to know something about how the cost for each method varies with volume of waste. If we let X_i represent the volume of waste processed by the i^{th} method then the cost for each method, c_i, can be written as

$$c_i = f_i(X_i);$$

that is, the cost of processing waste by the i^{th} method is a function of the volume of the waste.** Thus c_1 is the unit cost ($/ton) of processing waste by incineration; c_2 is the unit cost ($/ton) of processing waste by composting; c_3, c_4 and c_5 are the unit costs of processing wastes by grinding, ocean disposal and sanitary landfill respectively. Similarly X_1 is the number of tons of waste to be processed by incineration; X_2 is the number of tons of wastes to be treated by composting; X_3, X_4 and X_5 are the number of tons of waste to be treated by grinding, ocean disposal, and sanitary landfill respectively. Since we are considering five methods (as shown above) the total cost for processing the wastes would be given by

$$\begin{aligned}\text{Total Cost} &= c_1+c_2+c_3+c_4+c_5\\ &= f_1(X_1)+f_2(X_2)+f_3(X_3)+f_4(X_4)+f_5(X_5)\end{aligned}$$

or in abbreviated form.

$$\text{Total Cost} = \sum_{i=1}^{5} c_i = \sum_{i=1}^{5} f_i(X_i)$$

Finally our objective is to minimize the total cost.

$$\text{Minimum Total Cost} = \sum_{i=1}^{5} c_i$$

An obvious solution to this minimum cost problem would be not to process any of the waste, in which case each of the X_i would be zero and the cost would be zero. This solution is of little practical value. Although it minimizes our objective function it is obvious that the cheapest solution would be one for which we had no waste to treat. The fact is that we are required to treat a given volume of waste during each time period. This requirement is called a constraint in that we force ourselves to consider only solutions to the problem which will satisfy the requirements we impose upon it. For example, if $\underline{V}$ is the total volume collected (in a time period) then we can express the volume constraint as

$$\underline{V} \leq X_1+X_2+X_3+X_4+X_5$$

or more completely

$$\underline{V} \leq \sum_{i=1}^{5} X_i$$

This constraining equation requires that the sum of the volumes treated by each process (in a period) must be at least (≥) as large as the volume collected in that period. It should be noted that the presence of this volume constraint will no longer permit an all-zero (or trivial) solution.

** *This statement presumes that the cost of waste disposal for each of these methods is dependent upon the volume processed. If this is not the case, then this cost function would be invalid.*

A second constraint would be obtained if a limit existed on the amount (volume) of land available for landfill or disposal. Therefore the volume of material which could be processed by the methods requiring landfill disposal (i.e., incineration, landfill, composting, grinding) must be less than the capacity available for disposal. This constraint could be written as

$$D \geq \rho_1X_1 + \rho_2X_2 + \rho_3X_3 + \rho_4X_4 + \rho_5X_5$$

where D is the available volume at the disposal site. The constants ρ_1, ρ_2, ρ_3, ρ_4 and ρ_5 represent the fraction of the total volume of refuse treated by processes 1, 2, 3, 4 and 5 respectively, which must be buried at the disposal site. In this example $\rho_4 = 0$ (since ocean disposal requires no land); $\rho_5 = 1$ (since all the wastes are buried in a sanitary landfill); and

$$0 \leq \rho_1, \rho_2, \rho_3 \leq 1.$$

Obviously many other requirements should be imposed on this system to the extent that the system of equations will represent (in abstract terms) the real world in which the system must function. Generally, it can be shown that the value of the objective function (at minimum cost) will increase as the number of constraints increases.

When we find an optimal solution to this problem,† that is a minimum cost solution, we will simultaneously obtain the required operational information which makes the solution optimal. Specifically the operational variables X_1, $X_2 \ldots X_5$ are determined for the optimal solution. We have *not* made an *a priori* selection of the X_i but have determined the set of values which makes the total cost a minimum. Other useful information is available (at the optimum) since the solution usually provides shadow prices or marginal values which permit us to evaluate changes in constraints. For example one might be interested in answering questions such as, what increase or decrease in cost would result from changing V, the volume of waste which must be processed. This information allows us to consider methods of volume reduction in terms of trading-off the costs of on-site volume reduction against the savings which could be expected from using the processes shown above. The procedures involved in obtaining answers to questions of this type are given the name *sensitivity analysis*.

Sensitivity Analysis is an important aspect of mathematical programming solutions. Frequently it is impossible to place real limits on the constraints. For example, it is impossible to accurately predict the total volume of waste (V) which the community will produce. Consequently, it is useful to be able to determine the effects of changes in these constraints without computing each case separately. Under certain conditions sensitivity analysis can be successfully employed to evaluate *stochastic* aspects of problems.

A comment should be made about stochastric problems. Most of the mathematical development in systems analysis has dealt with so-called deterministic models. (A model is defined as abstract description of the problem.) These deterministic models are of the type described earlier in which the objective function and constraints were taken as given (and correct). It has been indicated that sensitivity analysis could be used to evaluate cases where uncertainty exists. However, there are many problems in which the variation of the elements of the problem over time must be considered - such problems are called *stochastic* or *probabilistic*. A great deal of effort is being given to development of techniques necessary to solve problems of this type.

In many cases it is difficult to describe a system mathematically and often problems may have a mathematical structure for which there is little hope of obtaining a solution. Under these conditions attention is frequently given to simulation studies. Simulation, in systems analysis jargon, is a procedure (involving the use of digital and/or analog computing devices) in which an operating model of the system is developed which will replicate the behavior of the system over time. It is possible to construct such a model when the over-all behavior of the system cannot be described if the following conditions can be satisfied: (1) the system can be separated into elements which are sufficiently well understood and can be described in detail; (2) operating

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† If the cost functions are linear, this problem is called a linear programming problem. A linear programming problem is characterized by a linear functional subject to linear constraints. See A. Charnes and W. W. Cooper, "Management Models and Industrial Applications of Linear Programming," John Wiley and Sons (1961).

rules can be established for each element; and (3) the interaction of every pair of elements can be described. A model of the entire system can be built up from these paired relationships. An input to any element passes through the entire system by following the operating rules which apply to each element and movement to the next element. If a sequence of possible inputs are processed, the behavior of the model over time can be studied and statistically recorded. The use of simulation in conjunction with high speed computers enables one to experiment with models of complex situations and examine their behavior over time. The computer compresses real time into very small increments of machine time with the result that "years" of operation of a system can be usually examined in hours or fractions of an hour of machine time.

The preceding paragraphs were intended to convey some impressions of the systems analysis approach to problem solving in the context of a particular problem. It is obvious that the validity of an optimal solution is a function of the reliability of data which are used in the problem. While for many problems the optimal solution (e.g. the minimum cost solution) may be a "true" optimum if the data used in obtaining the solution are correct this minimum value is in itself not necessarily significant. Marginal costs or benefits for various alternatives which can usually be obtained from these analyses are frequently more useful in reaching engineering decisions than a specific optimal value. It should be noted that these methods (1) will provide answers to questions which are as valid as the data used to determine them; (2) can channel the efforts required to improve data to those areas where the most significant system improvements can be obtained; and (3) will produce results which are at least as good and generally better than those obtained by traditional methods. Finally a goal of the systems analyst (in the solid waste field) is to provide municipalities with generalized methods of solution (and general computer codes) that can be applied to problems in specific areas.

Comparatively little research has been directed specifically to application of systems analysis to solid waste disposal problems. However, many of the analytical techniques which have been developed for other problems can be applied to this area. A study of solid waste collection systems has been in process at Northwestern University for more than a year. Charnes, Quon and Wersan initially formulated two aspects of the collection problem - location of disposal sites and internal routing of collection vehicles. In the cases studied the objective is ". . . to make disposal site selections (or additions) in such a way as to minimize the total travel distance of all trucks to their respective sites.[‡] In this study three types of problems are examined: (1) where the disposal site locations are unknown variables which range over a given area; (2) where a set of eligible site locations is given and the best of these are to be selected; and (3) the location of additional or new sites to augment a set of existing sites." Charnes *et al* have directed their efforts toward developing mathematical programming and simulation models which can be used to solve the problems cited above. The mathematical results thus far obtained are of considerable value and interest. In addition they have begun testing a simulation program which was recently developed. This general simulation program is intended to provide municipalities with machine codes (or programs) with which they can analyze their own problems. In order to use this simulation model the local engineer or agency responsible for solid waste disposal operations will be required to provide certain statistical information which describe local conditions. Examples of the kinds of data needed are: the time required for crews of various sizes to load waste from individual households; variation in local weather conditions; time required for a vehicle to move from household to household; time required to travel from a household to a disposal site; etc. Such information is usually either available or can be obtained with a minimum of expense. The results of the simulation program will be valuable for testing alternative operational procedures and evaluating their consequences. Many variables such as numbers of collection vehicles, location of disposal sites, location of garaging facilities, effects of weather, etc. can be tested in this model.

[‡] *Charnes, A., J. E. Quon and S. J. Wersan, "Mathematical Simulation of Refuse Collection and Disposal Systems," First Progress Report to USPHS, Division of Environmental Engineering and Food Protection (RG-EF-00355-01) May, 1963.*

Wersan, S. J., J. E. Quon, and A. Charnes, "Systems Analysis of Refuse Collection and Disposal Practices," The Technological Institute, Northwestern University, Evanston, Ill., 1963.

There are many solid waste problems to which systems analysis can make a significant contribution. Some possible avenues of research can be illustrated by presenting questions which will require answers in order to obtain efficient operations of solid waste disposal systems.

1. Should collection vehicles originate and terminate in the same location?
2. Where should transfer stations be located? (This problem is an extension of the problem which Charnes et al are studying since household collections will be required independently of the transfer operations, but other factors must also be considered.)
3. What combinations of solid waste processing methods will result in a minimum cost when constraints exist on the disposal sites or processing methods?
4. What kind of processing methods should be developed or which existing methods should be improved to obtain maximum return for the dollars invested?
5. When solid waste processing and disposal are required, where should these operations be located?

The above are but a sampling of the many questions which require useful answers in order to achieve efficient operations.

In summary, systems analysis provides a tool for examining complex interrelated municipal activities and the solutions obtained by these methods provide a sound basis for reaching decisions. These analyses are not an end in and of themselves but rather are intended to serve the end of efficient and effective decision-making. Although some of the techniques used in these approaches may be abstract and mathematically complex the prime motivation for the analysis is to obtain useful results and solutions.

GENERAL DISCUSSION

CHAIRMAN XANTEN: Thank you very much. May I ask anyone present if they have any questions?

DR. McKINNEY: I would like to make a few comments on this general topic. Engineers for a long time have loved mathematical solutions. They want to put everything into specific numbers so they can arrive at the answer without any question. And I think this is very fine in many instances. But in environmental problems, we are faced with factors that cannot be expressed as specific numbers. This is where the real challenge is in systems analysis. There never will be precise data in dealing with sociological and political situations which may be much more overriding than the actual economic situation or the precise numbers the engineer puts down. And I think at times we are dealing with systems analysis as being a reasonably good exercise to run through, but then we have to toss the exercise out and base our decisions on something else.

I think, primarily for sociological reasons, we have to train young engineers to consider sociological and political situations as well as the grave mathematical situations. I would also include the minutia. Minutia makes the problem more complicated, and is the thing that ruins the practical system. Anyone who is concerned with a practical collection problem or a very practical sewage treatment problem, is faced every day with a certain amount of minutia which determines whether the problem works or doesn't work. I am not quite as sold on systems analysis as Walter, and I hope we can resolve some of these problems.

DR. LYNN: I would like to respond to your comments in detail. It is not the intent of systems analysis to offer perfect descriptive absolute values. We are not saying this is the only method by which you will obtain the best solution to the problem. Rather, given some information, we can find the best solution within the given set-up. If the information is correct, the solution will be correct. No method analysis will give you a better answer. What we are hoping to do is improve the procedure by which a decision can be reached. By examining the alternatives you are better able to reach a decision.

To illustrate, one of the city fathers may say for political reasons that a transfer station is inconceivable at a certain point, even though, from an operational viewpoint of the system it may be best. One would like to go to the city father as a director of public works and say, "All right, we can make this decision, but the cost of moving the transfer station will be $1 million more than our original proposal." It is then in the political arena that this man must make his decision. If he recognizes that the additional cost is in the range of a million dollars, he can then evaluate the proposal accordingly. Obviously, one cannot go to a city father, city council, or board or supervisors and say that they must choose the least costly way. But if you could give the person responsible for making the decision, some quantitative information, his decisions will be better. We are not making decisions; we are offering information in the process of decision-making.

MR. HARE: I would like to bring the level of this discussion down considerably, to us poor operators. We in Vancouver have started at the bottom. We have a project going which takes into account all of the variable factors in a block--the number of cans, the number of packages, the number of pounds per can, the volume. These factors can go into an IBM computer system, and we get the answers we need--the crew size, truck size, can size, all these things. We have gone into it far enough with our research people, and also with some of our brilliant young engineers who have come out of the university, to know that there is something valuable here. It will give you some operating answers.

DR. McKEE: I am in complete agreement with Dr. Lynn, and was very happy to hear his presentation. I believe that it is the duty of professors today to teach these concepts--systems analysis--along with differential equations, statistics, and of course subjects such as chemistry, physics, biology, and so on, so that when a young man gets out he will be equipped and know how to use these tools. You will find that industrial engineers, military planners, airlines operations officers, and others use systems analysis and operational techniques thoroughly, and they have found it does pay off. An airline has just as many abstract sociological problems as we have in refuse collection. Yet they do use this technique and they may vary their airplanes, crews, and everything else, to go on a certain schedule. We are no different actually from these other branches of professional activity where they have used operational analysis and systems engineering very effectively.

MR. RODIE: I think we would all have a better appreciation of this work that is being done at Northwestern, if we knew a little more about the exact status of it. I take it you are collecting data from Winnetka and applying systems analysis method to it? Has this gone on long enough to produce any results?

MR. WERSAN: The program has now just been written; there are no sound results yet. One of the rules of the program is to put in cases that you recognize as simple and trivial and see if they predict what common sense says they should. This is being done.

PROF. CHARNES: We are interested in probing the minutia to find how detailed a model is necessary in order to give results which are comparable to operating results. But making a worth while model is not something that a mathematician sits down and does when someone informs him of the facts of the situation. Every model involves abstractions. It involves explicitly considering some factors or some minutia and then checking back. Is it giving correct predictions? A good model requires a feed-back process. You have to start with something simple, check it, put in perhaps additional details, and check again. Only after you have something reasonably predictable can you go ahead and extrapolate or derive a policy.

CHAIRMAN XANTEN: Gentlemen, I am sorry--it is time for us to end this discussion.

Transfer Operations

F. R. Bowerman
Assistant Chief Engineer
Los Angeles County Sanitation Districts
Los Angeles, California

Present day systems for the collection and disposal of solid wastes consist largely of logistical relationships which are virtually the diametric opposites of usual systems of supply. The milkman on his daily route usually receives his supplies from a centrally located depot, which in turn is supplied by one or more dairies at some substantial distances. If the dairy is nearby, the milkman can pick up the dairy products directly, but in metropolitan areas this would necessitate an unreasonably large amount of travel for each of the route vehicles; an intermediate distribution center becomes an economic necessity.

In refuse collection and disposal, the route vehicle stops at each home or commercial house or industry to take on board an increment of waste material and, having completed the route or filled the truck, proceeds to some point, at which it must discharge its contents before it can continue the primary collection function for which it is designed, built, and operated. Where a sanitary landfill or incinerator is located within a short travel distance of the refuse collection route, the full truck travels directly to the point of disposal, discharges its contents, and returns to the collection route or garage. Metropolitan growth often results in situations where such short-range hauls are not feasible and an intermediate step must be provided to minimize the overall costs.

The transferring of refuse from the relatively small collection vehicle with its limited payload to a large bulk-hauler is not a new practice; such systems have been in use for a number of decades. Some earlier systems developed from attempts to salvage certain portions of the solid wastes, with rejected material being hauled away for final disposal. An example of such a system exists in Detroit where a salvage operation, commenced largely for the salvage of tin through the "detinning" of tin cans, ended with the abandonment of the salvage operation and the utilization of an overhead crane and storage pits for the transfer of refuse to large volume truck-trailer combinations. More recently, systems have been designed and built expressly for the transfer of refuse to highly specialized highway-type bulk-hauling equipment. The design of such transfer stations is divided into two basic categories: one in which the refuse is dumped from the collection vehicle directly into the trucks or trailers which haul to the final disposal site; another in which the solid wastes discharged from the collection vehicles are subjected to special handling for loading into the transfer trucks or trailers.

Direct Dump Transfer Stations

It is an axiom in materials handling that each time a material is re-handled, the total cost rises; this is the principal advantage that direct dump transfer stations have over other types using storage and re-handling. However, another equally important axiom in materials handling is that intermediate re-handling steps are justifiable if the net effect is a reduced unit cost for handling. Usually the latter results from a compacting step which increases the density of the material and allows more units of weight to be handled in the same space.

State motor vehicle codes usually stipulate permissible gross tonnages for highway hauling and add certain limits on wheel and axle loadings. Limits on overall length, height, and width of hauling equipment also provide an upper ceiling for permissible volumes. The engineer, faced with these legal limitations, works backward from them to establish sizes of units and distributions of axles which provide for the largest feasible volume, thus insuring a maximum uncompacted payload. For direct dump transferring, this concept is basic, inasmuch as the compaction that can be achieved through "top tamping" of loads is at best nominal. It is calculated that at the direct dump transfer station operated by the Los Angeles County Sanitation Districts, loads dumped into the open-topped trailers are increased on the average from about 300 pounds per cubic yard to 350 pounds per cubic yard through tamping with a small hydraulic crane. Although this density change is not very dramatic, it is all that is necessary (or permissible) because of the gross vehicle weight limitations. In other words, within the useable volume of about 120 cubic yards, a payload of some 22 tons can be placed; to exceed that amount would violate the California State Motor Vehicle Code for gross vehicle weight. A small mobile crane is necessary at direct dump transfer stations not only to provide nominal compaction, but to level the tops of loads so that they do not extend too far above the trailer; the design of the trailers, based upon a height limit above the ground of 13 feet, 6 inches allows a few inches of leeway under loaded conditions because of spring deflection.

For most state motor vehicle codes, the optimum configuration for maximum tonnage payloads will be one in which the spacing and number of axles will allow an upper limit of combined dead load and live load to the maximum permissible gross vehicle weight. In California, the maximum gross vehicle weight is 76,800 pounds; a diesel truck tractor pulling a semi-trailer mounted on the truck tractor's fifth wheel, with a full trailer coupled to the semi-trailer, is the vehicle configuration which permits maximum payloads.

The trailers are built identically for easy substitution; the full trailer is created from the semi-trailer through the use of a converter dolly for the front wheel assembly. Table 1 shows the numbers and costs of units presently in service at the Sanitation Districts' South Gate Refuse Transfer Station; the equipment is suitable for an operating level of about 120 tons daily. The raised platform provided at the Districts' direct dump transfer station has sufficient dumping bays to provide for eight trailers, each 25 feet long, to be placed beneath deflecting hoppers at the same time. This trailer capacity provides for the receipt of peak surges during the day and is, in a very real sense, a substitute for the storage pits found at incinerating plants and other types of refuse transfer stations. District experience with the station for the past six years shows the operation and maintenance costs to have averaged about $2.49 per ton; adding the cost for disposal at District landfills of $1.00 per ton and about $0.19 for amortization of the station's facilities would raise the disposal costs at the transfer station to $3.68 per ton. That figure is about equivalent to the operation and maintenance costs and amortization charges for municipal incinerators.

Transfer Stations Utilizing Storage and Re-handling

The ultimate goal of refuse transfer stations is to provide for the transferring of refuse at an optimum spacing to minimize non-productive travel of refuse collection vehicles. A decade ago, when collection vehicles were hauling average loads of from 3 to 5 tons and the collection crew comprised a driver and two helpers, the optimum distance between refuse transfer stations in metropolitan areas was about 6 miles. Today, refuse collection vehicles

Table 1
Equipment for a Direct Dump Transfer Station*
(120 tons daily capacity - 45 mile round trip haul)

Unit & Type	Number of Units in Use	Average Purchase Price (Per Unit)
Trailers (Pull-off unloading)	14	$ 4,800.00
Trailers (Self-unloading)**	2	8,000.00
Trailer Converter Dolly	9	1,600.00
Truck Tractor (gasoline)	2	9,000.00
Truck Tractor (Diesel)	2	14,000.00
Hydraulic Crane	1	13,000.00
Power Sweeper	1	3,000.00

** Capital cost of transfer station including 30 ton capacity automatic weigh scale $160,000. (Not including some 3 acres of land).*

*** Unloading mechanism later removed in favor of cable pull-off unloading.*

sometimes carry 5 to 7 tons and sometimes utilize only the driver during the trip to the disposal site; under such circumstances, the optimum spacing of transfer stations is from 15 to 20 miles. This extension of the radius of economic collection from about 3 miles to from 7 to 10 miles has the effect of increasing the optimal capacity of each transfer station, since a much larger service area is tributary to the station.

The Districts' experience with the one small direct-dump transfer station has led to the inescapable conclusion that such a procedure is not practical for tonnages of 400 tons daily or more and larger stations should logically be built with provisions for storage of peak loads and prompt, efficient loading of transfer vehicles. A number of schemes appear to be competitive: the use of pit and crane for overhead direct loading of trailers or for feeding of refuse in steady, controlled quantities into hoppers which in turn feed to compacting pistons which end-load the transfer vehicles; the use of shaker pans or belt conveyors designed to accept sudden influxes of large quantities of refuse and capable of feeding a steady stream of refuse to the transfer vehicles; the use of containerization or baling as a step just prior to loading the transfer vehicle. The ingenuity of the design engineer will be needed to provide a mechanized system of materials handling which will remain relatively free from breakdowns and outages, while handling what may well be the most heterogenous assortment of materials for which such systems have ever been designed.

Future Trends in Transfer

Most solid waste transportation systems utilize automotive vehicles exclusively; it is safe to say that the one major change in solid waste collection in the last 100 years has been the conversion from horse-drawn wagons to gasoline-powered trucks. No crystal ball is yet clear enough to see a completely satisfactory alternative to the current practice of door-to-door collection, but some glimmer of hope lies in the present day usage of garbage disposers for ridding the solid waste collection system of the most likely source of nuisance. It is entirely possible that an extension of the concept of food waste grinders to include other solid wastes will prove both practical and economical. At best, our present technology suggests that grinding at each individual home may not be practical because of the inherent problems in providing a grinder capable of handling the many types of solid waste which could be carried in the sewer.

It goes without saying that non-combustible rubbish such as cans and bottles, and large, awkard objects such as tree limbs, would of necessity have to be collected through the usual procedures. The grinding of only a portion of the combustible rubbish to the sewer at homes would not be justifiable, since, if the collection vehicle makes a periodic stop at the home, it costs very little more to pick up all of the rubbish than it does to pick up only a portion of it.

It does appear that some merit exists in grinding rubbish to the sewers at transfer stations where the solid waste unsuited for carriage in the sewer would be hauled away for disposal elsewhere. With such a system, the sewer serves as an "endless belt" type of conveyor to deliver the ground refuse at nominal cost to sewage treatment plants where it will be extracted for disposal along with sewage sludge. Many unsolved problems lie along this path, but with the use of centrifuges for economical dewatering of sludges and the composting of the sewage-refuse mixtures, such systems may prove to be an economical means of transporting certain portions of solid waste at less cost than by truck.

The Los Angeles County Sanitation Districts have run feasibility tests on the anaerobic digestion of sewage-refuse mixtures as well as on the aerobic composting of such mixtures and the results appear promising. In a recent test, the Sanitation Districts fed some 7 tons of ground combustible refuse to a trunk sewer during a period of about 30 minutes. Observations at manholes downstream and at the sewage treatment plant showed that the ground refuse was readily transported through the sewer, including inverted sewer siphons, and caused no difficulty until it reached the bar screens at the sewage treatment plant. It was concluded that a somewhat finer grind than the 3-inch to 4-inch size as was used in the test would have readily passed between the bar screen openings for removal in the sedimentation tanks; however, the larger particles overloaded the screenings grinder which normally handles a very much smaller loading from sewage. It is probably that either a modification in the inlet works screening or the grinding of refuse to a maximum size of about 1-inch or less would be necessary. The Los Angeles County Sanitation Districts expect to continue studies directed along this line of research in the hope that this method of transfer and transportation may provide some future solution to the ever-increasing costs of over-the-road transportation.

GENERAL DISCUSSION

CHAIRMAN XANTEN: Mr. Bowerman, Have you ever considered burlap as a cover?

MR. BOWERMAN: Yes, burlap is used by quite a few of the private operators in Los Angeles County; but we found burlap, even though cheaper and easier to replace, gets fouled up with twigs and things like that, and becomes so unsightly we just gave up on it.

CHAIRMAN XANTEN: Are you in any way responsible for the treatment of sewage?

MR. BOWERMAN: Yes, The County Sanitary District in Los Angeles operates nine sewage plants, as well as the five sanitary landfills and the one sanitary station.. We are willing to study the potential use of the sewer as a transportation system, realizing that we have ahead of us many problems at the disposal plant.

As Dr. McKee pointed out in his keynote speech, the dry tons in sewage are in small proportions to the dry tons in solid wastes. So, if we grind the solid waste even to the trunk disposal system, we multiply the problem at the sewage disposal plant by about five times. In so doing, we recognize though, that there are convenient methods for de-watering. As a matter of fact, we have done about a year and a half of composting, utilizing mixtures of sewage sludge and refuse, in order to gain experience. We are convinced that the combined operation may prove to be cheaper in the long run, particularly because, with the amounts of water flowing in our sewers, we can use the energy available there as the conveying system to get to the treatment plant. There is some additional sewer maintenance but this is small. We feel that we should not be spending so much to operate transfer trucks.

CHAIRMAN XANTEN: I am interested in this subject, because I have been operating a four ton an hour garbage grinder at our transfer station. It is near the main sewage pumping station, but our sludge disposal problem is already so great that I cannot transfer the problem down there. A belt conveyor leads to the grinder and easily could be used for picking off the material that should not be ground. I don't believe the grinding or the shredding is the problem. The problem is sludge disposal. Here is a place for some research.

PROF. GINGLES: What is the necessity for grinding material removed from the screens? Wouldn't it be simpler to take it out and not pass it through the rest of the plant? You mentioned this as being a desirable size for grinding. It would seem to me the larger the material you can get out without having to carry it, the less load you would place on the plant.

MR. BOWERMAN: You are quite right. If we started out to design a rubbish grinding sewage system, we would probably use some rough screens and take off the material without putting it through the grinders. Actually what we do is simply dump it into an existing system designed to handle a modest amount of screening. Actually the design changes would be quite nominal, even though the increased solids would be quite great. The increase would be in the digestion system; it would not overload the sludge-collecting system. It might increase the need for sludge transfer, but sludge digestion would be the one place where the effect would be felt quite greatly.

PROF. GINGLES: Since you have successfully demonstrated the possibility of carrying the ground refuse in the sewer, have you given any consideration to transferring refuse to the disposal site by means of pipelines such as the slurry transfer of coal and oil and other various products?

MR. BOWERMAN: They are doing it with coal. I don't know why it can't be done with ground rubbish. Los Angeles, has a sewer system costing several hundred million dollars. The longest pipelines run more than forty miles, so we have an expensive network already there. If we can use it, we don't have to put out new capital. But I think you have a good idea for areas where you might want to get outside of the community, by pumping out a slurried refuse to a landfill or something like that. I think it could be done.

MR. FRANKLIN: Is it conceivable to use a rail piggyback transfer system.

MR. BOWERMAN: We didn't have to do that when we made our earlier studies on rail transportation, but I think this is a feasible answer for some communities. In the Los Angeles area we found that the number of rail centers willing to accept this type of material, were limited. That is, we couldn't find the ideal locations where we wanted them.

Secondly, the railroads told us that over-the-highway truck transportation was cheaper for everything up to 150 miles, and beyond that, they could start talking business with use. But this was before the piggyback concept -- more than ten years ago. That is a good suggestion, and I might go into it.

MR. HARE: We investigated rail transportation for a twenty-mile haul and it was not economical. This was within the last two years, and the answer was the same. If they were going to haul one hundred miles, it might be economical, but for short hauls, it becomes too complicated. There are too many pieces of equipment involved, and there would not be any economy.

MR. BOWERMAN: We only have to go fifty miles and we can find canyons that will last us a hundred years.

Coming back to Jack McKee's comment yesterday on bailing, you can get a 90-ton limit on a rail car. To put that much on it makes good sense. By bailing you get closer to a payload on a rail car.

CHAIRMAN XANTEN: In the case of incinerator residue, the payloads are large and the railroads are vitally intersted. Most highway bridges won't take the load limits, nor will the roads.

CHAIRMAN XANTEN: It is time for us to adjourn. Thank you Mr. Bowerman for your excellent presentation, and thank you for staying with us through this session.

Containerization

Philip E. Shayne
Executive Secretary-Treasurer
Detachable Container Association
Washington, D. C.

I would like to begin my presentation with a few words about the Detachable Container Association. DCA is a national association of trash removal contractors who provide containerized service to industrial and commercial customers. As a trade association, we are concerned with such problems as developing industry standards, working on solutions to customer and public relations problems, and applying economic principles and up-to-date business practices to the industry.

In serving the needs of our industry, the association also serves the public, because its members are playing an increasingly important role in the solid waste removal problems which confront all of us.

As we have heard in previous speeches, the public does have a problem, and it certainly is not a new one.

Human discards, which we refer to today as solid wastes, are as old as civilization. They are probably as old as the human race itself. From the piles of animal bones and half burned sticks left by cave men we can trace much of our ancestors' way of life. We can determine how long ago they existed, and even the kinds of game they hunted.

Throughout the Middle East the remains of ancient cities appear above the level plains as high plateaus. Archeologists tell us that the ground level of these ancient cities rose gradually, due to the custom of dumping trash and garbage in the streets and on the floors. When things got too thick underfoot new mud floors and streets were laid. You might call this the first unsanitary landfill. Trash heaps around these sites have told our historians much about ancient cultures.

In medieval towns trash was hauled away by donkey cart to a nearby dump. One medieval trash man even gained some renown by being the father of Saint Bernadette. His job, when he had one, was to haul solid waste from the local hospital to the nearby dump, which was near the Grotto where Bernadette saw her visions.

American Indians simply carried their refuse out into the woods and left it. This method was imitated by early farmers and settlers. As cities grew, organized systems for collecting refuse and burning it were developed. Except for changing from horse and wagon to motorized trucks and the adding of a hoist lift, little change was made until the first packer trucks appeared, and not a moment too soon.

With the help of Madison Avenue, and our increasing affluence, the average American now produces about 4 to 5 pounds of rubbish each day, according to one estimate. Everything comes wrapped and packaged - even a pair of sox. Some of the prepared dinners contain a variety of cans, bottles and boxes, all of which are thrown out when the meal is consumed. The problem is serious for the householder; it is serious for commercial establishments. The problem is going to get worse, and the challenge to all of us is going to become greater with every passing year.

I would like to describe some of the various types of Container Systems in use throughout the country, and point up some problem areas in the industry which research might solve.

First, what is a container system and what is a container?

A container is a fancy word for trash can. You have waste baskets and trash cans in your house. You try to place them near your work areas. This saves you time and energy. This is the same basic principle on which container suppliers work.

A container system is a partially mechanized, self service trash removal service. It is self-service in that the customer puts the trash in the container. It is mechanized in that special equipment is used to empty the containers and to haul the trash to a dump. In some instances containers are on wheels, placed inside buildings. By putting the trash container at the point of trash origin, a container system helps cut down work time and save labor costs. In some instances the container is picked up, removed to the dump to empty, and then returned.

In some instances the trash is compacted right at the point of origin through the use of a permanently installed stationary packer.

I believe you can get a better idea of the various systems by seeing some of the equipment which is used. Basically, there are six types of detachable container systems.

The first type is one in which the driver uses lifting arms. He backs up to the container and attaches lifting chains to the trunnions. He returns to the cab, hoists the container to a carrying position, then lowers the boom rest to be ready for transporting to the disposal area. This type of unit handles 3-, 6-, 10- or 15-cubic yard containers. Let's refer to this as LC (lift and carry).

A second type consists of roll out containers of 1- to 3-cubic yard capacity that are hoisted at the side of the truck and emptied into the truck body. The container is left with the customer. These compaction trucks can handle as much as 30 cubic yards of compacted solid waste. This is SL meaning Side Loader. A third type of container system is called RL (Rear Loader).

The Front-end Loading System is called FEL, and handles containers from 1- to 10-cubic yards. Arms engage the container, move it up over the cab and dump the contents into the truck body. The container is then returned to its original location. A compaction device both packs and pushes out the refuse.

A unit called the PO (Pull On) handles the largest detachable containers with capacities ranging up to 40 cubic yards. Larger containers are also available. One man operates the truck from simple controls in the cab. The container is picked up by a hydraulic device and carried to the dump for emptying. There are also Cable Systems with which maximum weights can be up to 30,000 lbs. over-the-road gross.

The latest type of equipment is the (SP) stationary packer. This is really an adjunct of the container system. It consists of a huge container -- up to 50 cubic yards -- which is picked up by a truck, is dumped, and returned to the customer. Loose trash is fed into it and compacted into the container. Compaction reduces the volume of the solid waste by 75%. Obviously, this type of equipment is more efficient. Containers for use with stationary packers are available in sizes ranging from 15 to 50 cubic yards.

There is little doubt that, containers are a big improvement over the old row of open cans and trash bins. Containers are fireproof, animal proof, rodent proof and fairly free of flies and odors. You can get more into them than in the old fashioned cans. In these respects, container systems are contributing to the solution of our solid waste problems, but before containers can make their maximum contribution to the safe storage and transportation of solid wastes, there are still more serious problems to solve.

I said a while ago, that containers represent a partial automation of the trash removal business. As you might suspect, the parts which remain non-automatic, are the source of our greatest problems.

The number one problem in the container industry today is cleaning the container. Actually local Health Department Authorities hold the customer responsible for keeping the trash containers on his premises in a sanitary condition, but the customer also demands this service of his trash removal contractor. Because of the manpower and time it takes, cleaning containers raises the cost of the service considerably. Collection trucks, because they represent such a big investment, have to take in about $30.00 an hour (Productive Time), or 50¢ a minute. It takes about 5 minutes to clean the container. That costs us $2.50.

There is no easy way to clean out a container. With containers that store trash, those that need washing out are not office building or garage containers, but rather ones which contain foodstuffs, which are produced by restaurants, apartments, food stores and others. The only way you are going to clean such a container is by scraping the bottom and sides free of all residue, and then spraying it with a disinfectant solution under air pressure. We use a sidewalk scraper to get loose material out. This produces a sanitary can, but while the men are doing it, the packer truck stands idle.

Three methods are commonly used to clean a container: (1) spraying a disinfectant sanitizer into the emptied container, (2) steam cleaning it, or (3) applying hot water and disinfectant with a turbo-like spray.

We have found that in fulfilling a certain difficult contract, hot water and soap will do a satisfactory job. Various methods have been tried and suggested. One health official recommends using borax and bicarbonate of soda, 1 cup of each in 5 gallons of water, to spray the container to kill larvae and get rid of flies. This is not harmful to animal life, and does an effective job. Plastic liners have been suggested, but these have disadvantages and are expensive. Everyone agrees that all putrescible food matter should be wrapped, but this involves training the customers, which is not always possible.

What is really needed is some automatic method of cleaning the container that would be efficient, save time and eliminate the possibility of human negligence. This is a considerable problem too. There must be some way to devise a detergent spray which could be directed at high pressure into the container, perhaps when it is partially tilted over the truck, but this remains to be invented. What I have in mind is the cleaning and disinfecting of containers while they are in a dump position above the truck.

Finding better ways to clean containers is not the only problem in the industry. Architects should pay more attention to the containerization of trash removal for their buildings. At the place where containers are picked up there should be a hot water line and a drain so that containers can be flushed by the user after dumping by pulling a lever. Ways to clean containers both inside and outside buildings should be provided. Few existing buildings have these facilities, and what is even more important, few plans for new buildings are incorporating them for containerization. An educational job needs to be done here. If building facilities do not keep pace, it will slowdown the further mechanization of the industry, and raise the cost of the service.

Manufacturers now have chemical detergents for disinfecting and sanitizing containers, and one health officer in the Surgeon General's office feels a major problem in the industry would be solved if a good grease-cutting chemical were found, and more frequent pick-ups could be arranged.

There are other problem areas as well. One is in recruiting, training and holding the kind of personnel who can responsibly operate this expensive equipment. What can you do for a man, or say to him, that will make him feel that he is a part of an important service industry? -- How can you give him the concept that the industry is constantly expanding and can provide some measure of security if he wishes to remain on lower levels, or some opportunity to advance if he has the ability? Perhaps some social scientists can find the answers to these questions for us.

One other problem that might be studied by psychologists or sociologists is the devising of a new name for drivers of trash collection trucks. Actually, this activity is far different from trash collection as it has been known. A more appropriate name would be a great help in solving some of our personnel problems.

In the area of business practices, systems analysis is already being applied. At least one major study on the application of systems analysis to refuse collection and disposal practices has already been made at the Technological Institute at Northwestern University in Evanston, Illinois. Our industry, like most others, can benefit from specific application of such other techniques as time and motion and efficiency studies, and mechanizing office procedures.

Much technical progress has been made. In our own plant, our project engineer developed and patented a truck. Other studies and experiments are underway. There always is a need to increase automation without increasing the complexity of operation. Some of the present equipment might be simplified. Future equipment can be designed with personnel limitations in mind.

We could use container lids which achieve a tighter closing and help keep out the flies. Balanced lids make it easier to deposit trash in the container. These might be better adapted to our types of containers, so that they also keep out flies.

False bottoms to containers could be adopted by inserting a removable tray to clean out the bottom of the container and replace it with a clean tray.

The best material we have for containers now is steel covered with paint. Research so far has not proved aluminum or fiber glass any better, but a lighter weight non-corrosive container would certainly be an improvement. So here is a research job for material engineers.

As long as steel containers are used, there is room for improvement in paint. Our containers have to be repainted on an average of every 12 months. Some companies are using rust-proof undercoating. A long wearing coating of this kind would help solve the problem.

Beyond this, I believe all research in the detachable container systems industry, as well as in refuse disposal, needs to be done with the future in mind. As we have heard, landfill sites are disappearing. Open dump areas are getting scarce, and being located farther and farther away. Burning is prohibited in many areas, and incinerating is only a partial solution. It is not inconceivable that a time will come when solid wastes must be shipped, perhaps on flat cars, to distant deserted mine pits and other areas, the way atomic wastes are disposed of in containers in the ocean. Los Angeles is already hauling trash 22 miles - 44 miles round trip. Containers can be designed which could be used on flat bed rail cars or trucks for long distance hauling. One colleague humorously suggests that perhaps we should begin to design containers which are rocket shaped for orbiting in outer space.

In all seriousness, I think we can agree that the problems involved in transporting and disposing of solid wastes are becoming increasingly frustrating. The industry as a whole is beginning to experience a frustration similar to that of a Pennyslvania farmer we heard about, who developed a unique container system of his own. He did not live in a jurisdiction which has regular trash collections. When the debris would begin to get ahead of him, he would look around for a nice strong box -- perhaps a suit box, a hat box, or a large gift box. He would fill it with solid waste, wrap it in white paper, tie it with pink ribbon and set it at the side of the road which passed by his property. Without fail, some Cadillac, or Chrysler, would come to a stop, a person would get out, look furtively around, snatch the "detachable container" and speed off to explore his treasure. The system never failed for the farmer, but I'm afraid this one won't work for us.

However, it would behoove us to use that kind of creative imagination to solve some of the research problems which, as I have pointed out, are now blocking the efficiency of the detachable container industry.

Safe, sanitary temporary storage for solid waste, and the efficient removal of solid wastes is becoming increasingly necessary as populations become denser. By improving detachable container systems, we will be taking one necessary step toward the solution of the whole refuse problem.

The archeologists of the future may not be able to trace our culture through our trash heaps, but let us hope that they can read of our intelligent handling and ultimate solution of this unique and growing problem of our affluent civilization.

GENERAL DISCUSSION

CHAIRMAN XANTEN: Thank you, Mr. Shayne. That was a fine presentation.

DR. LYNN: It has occurred to me that there seems to be a waste of energy in compactors. Garbage is picked up, compacted, taken to a sanitary landfill, discharged, and recompacted by some other type of vehicle. Has the compacting or packing industry, considered the possibility of bundling within the packer itself? This is a technical problem, but one the refuse is in compacted in the truck, why not tie it before discharging at the landfill site?

MR. SHAYNE: Refuse can be transferred from a stationary compactor to a packer body, so maybe there should be a disposal packer body. Actually the refuse is pretty much compacted when it comes out of the compactor body. It stays pretty close.

COMMENT: Why are we worried about conserving space in the landfill? Refuse will, by the process of disintegration, conserve that space over a period of time anyway; so all you lose is the volume of the first cover you put in.

DR. LYNN: But we still must recompact this material after it is discharged at the landfill site. Since we have already compacted this material in the vehicle, let's take the compressed cubes and lay them alongside one another!

COMMENT: You will need a machine as big as the D-17 to do that.

DR. LYNN: From the standpoint of the vehicle manufacturer, I think it could be handled when the vehicle is full on the way to the dump site. Some way to take advantage of this compressed state could be used by perhaps adding a coverage of cardboard inside and strapping it and depositing it as a cube at the fill.

CHAIRMAN XANTEN: We will get on with the next paper. Thank you very much.

Equipment Development

Otto Kuehn, Chief Automotive Engineer
Bureau of Equipment Service
City of Chicago, Illinois

The development of changes and advancements in refuse disposal trucks over the past ten years, has been very limited. Perhaps, the most revolutionary change has been the ejector plate for removing the refuse from these units, rather than dump type removal. A study should be made of which size unit is the more economical from the standpoint of compaction. At the present time, a 10 or 12 yard body will hold far more refuse by weight, per cubic yard, than proportionately can be put into a 20 or 25 yard unit. Will the ejector plate type overcome this difficulty? This and other related research problems will be discussed at the end of each main subject.

Refuse Trucks

Body

1. Size. The size of the refuse disposal truck body hinges on three items:

   a. Weight which is a direct function of compaction.

   b. Type of refuse collected. Will it be more economical to have segregated refuse and pick up wet refuse each week and dry refuse twice a month?

   c. Economics of loading time, that is, is a unit large enough or small enough to make two loads a day to the incinerator. If the unit is too small, or too large, there is a great deal of wasted time so far as the laborers are concerned.

2. Type. There are two types of bodies now in use. The more prevalent is the dump body, and the latest innovation is the ejector plate body. There does not seem to be much difference in the weight of these units. In one case, the ejector type weighed 600 lbs. less, while in another manufacturered product, it weighed 970 lbs. more. These figures are quoted for a 20 yard unit. The hopper on both types seems to be about the same size and capacity. There is, however, one type of body that increased its hopper width from 37 inches to 51 inches. This, naturally, speeds up the filling time. There is a tendency at the present time, especially on the ejector plate type, to increase the pressures up to 2,500 lbs. per square inch. This will speed up the loading cycle and should help to give better compaction.

3. Research. The following items would each make a very fine project, to simplify tail gate assembly, speed up loading time, and cut down on the weight of the body. Simplifying the tail gate assembly by increasing the pressure and decreasing the size of the cylinders and changing from steel to aluminum bodies and increasing the size of the hopper for faster and greater capacity loading. These items should certainly be examined in the next few years.

Chassis

1. Weight. The maximum GVW of a 20 yard garbage truck is, when loaded, approximately 31,000 lbs. The actual weight of the chassis and body must be held to a minimum. Manufacturers of frames should start experimenting with the use of aluminum frames and cross rails, which are just as strong and easier to work with. They would weigh 50% less than steel. Also, the use of plastic material on the hood, fenders, etc., would save 25%-50% in weight. These items are all very important since we would like to stay around 30,000 GVW so as to stay with a single rear axle on the chassis.

2. Engine. The cubic inch displacement of an engine does not have too much bearing on the HP output. A smaller cubic inch displacement, the higher the r.p.m. of the engine to obtain a certain HP. It is therefore, more advantageous to have a larger cubic inch displacement and a lower r.p.m. for the HP required. We, in the City of Chicago base our engine size on the HP and torque output in the following formulas. Our required HP is around 3200-3400 RPM at governed speed:

   G.A. which is Grade Ability in first (1st) speed with a 10% factor of safety, should not be less than 20%.

   The formula:

$$G.A. = \frac{.85 \times 1200 \times T \times R}{31{,}000 \times 19.6} - 11.2 = 20\%\ \text{Minimum}$$

   where
   T = Net Torque
   R = Total Gear Reduction

   We also require a net HP that is sufficient to drive the truck when fully loaded up a 3% grade @ 40 m.p.h.

   The formula:

$$MPH = \frac{37{,}500 \times HP \times .85}{(3\% + 1.2) \times 31{,}000} = \text{Min. } 40\ \text{MPH}$$

   Since practically all large cities have gone into the building of expressways, it is now necessary for our refuse trucks to travel these expressways at the required speeds which vary between 40-50 m.p.h.

   We therefore have a formula for m.p.h. in direct drive at governed r.p.m.

   The formula with 10:00 x 20 tires is:

$$MPH = \frac{.116 \times R.P.M.}{R} = 45\text{-}50\ \text{MPH}$$

   where R = Total reduction in high speed.

   A very helpful research program would be to come up with a group of formulas as listed above which would be accepted by all municipalities and manufacturers. The one item that always disturbs engineers is the fact that engine manufacturers always show HP and torque as gross figures. In the formulas above, we naturally must use net HP and net torque figures. A uniform method of arriving at these answers, acceptable to the entire industry, would be a great step forward. The above formulas should be applicable to gasoline, diesel and LPG engines.

3. Clutch and Transmission. Today, most of our transmissions are synchro-mesh type units with a single disc clutch. The life of the single disc clutch is quite low. There are two methods which can be used to overcome this difficulty. Using the old twin disc clutch with a brake on the counter-shaft using spur gears, and the lubrication by means of an oil pump circulating straight mineral oil. The other method is to go to automatic transmissions, thereby eliminating the use of the clutch.

4. Rear Axles. There are three types of rear axles now in use in garbage disposal units.

   a. Regular rear axles.

b. Double reduction.

c. Two (2) speed.

In Chicago, we use nothing but double reduction rear axles and we have proved to everyone concerned that it is good economy to pay the extra $200.00-$300.00 charge for the double reduction unit. The major portion of our fleet goes through its entire life without any servicing of the rear axles. We have been using the hypoid helical double reduction design and the spiral bevel planetary design. It is felt that the hypoid helical gears give a better balance between the two sets of gears.

5. Speed. This subject is covered quite clearly in the discussion above; however, it should be re-emphasized that with the great number of expressways and thru-ways, it is necessary for the refuse trucks in large cities to travel at high speed. With the 20- and 25-yard units, it perhaps becomes necessary in units that do not have sufficient HP, to use either two speed differentials or auxiliary transmissions with an overdrive.

6. Lubrication. A great deal of research should be done in this area, with the great improvements made in metals and the fine heavy duty motor oils we now have. Have we reached a point in refuse disposal equipment, where the preponderance of our engine work is done while operating with an off-speed idle, and where our heavy duty motor oils do not allow the piston rings to seat themselves correctly? The recent innovation of using "Oil Mist" lubrication for chassis work, has been quite successful in the City of New York. This is only for lubricating chassis parts at given intervals. It is suggested that some research be done to try to use this system for also lubricating the body parts. If this is possible, it would certainly be a step forward in reducing the maintenance and wear of movable parts.

7. Ignition. There has been quite a bit of progress made in the past few years, with our ignition systems, our generators, etc. At the present time, most municipalities are specifying an alternator in their equipment. This has made a great saving in battery re-charging and replacements, especially in equipment where two-way radios are used. There are a number of transistor ignition systems on the market. At the present time, we have not been able to decide which type of unit is most successful. A research project in connection with transistor ignitions would certainly be appreciated by the municipalities. We do have a serious maintenance problem in connection with breaker points and spark plugs. Our limited experience with transistorized ignitions shows a vast improvement in these items. A comprehensive study of various systems in conjunction with the great amount of idling and also high speeds required on the expressways and through-ways, would be valuable.

8. Preventative Maintenance. This, perhaps, is the greatest questionable type of work performed on vehicles. However, how far should they go in checking, how often should they be checked and how long should it take to perform these duties? All the major oil companies have very fine Preventative Maintenance charts listing what should be done and how often. The same goes for the chassis manufacturers. However, when it comes to a specialized type of work, such as that involving refuse disposal trucks, no one has yet come up with a good, successful, and logical Preventative Maintenance Program.

   Our vehicles travel approximately 1,200-1,500 miles per month. During that time, the engines have travelled approximately 4,000-5,000 miles, due to fast idling while the truck is being loaded. This always brings up the question, should PM be based on truck miles or engine miles? What are the most important items to check and adjust and hold the work down to approximately two (2) hours per vehicle for the mechanical inspection and adjustment? This would also include the checking of the body hydraulic system and the pressure and cycling time of the unit. In municipalities, it sometimes is quite hard to get men to do a certain type of PM work, unless the vehicle is down for that particular trouble. We, in the supervisory capacities, feel sure that if the PM was done correctly and thoroughly, a great amount of the present day down-time, would be avoided. Maybe, somebody could come up with some method to get this type of work done without an over-abundance of supervisory personnel.

The City of Chicago is now working on a specification, to be submitted to the chassis manufacturers, on a Guaranteed Maintenance Program. This specification covers six (6) years of operation and would include everything, except tires, fuel, motor oil and complete paint jobs, when needed. To help the chassis manufacturer to come up with a realistic figure, it is proposed that the body specifications be bid approximately three (3) weeks prior to the chassis bid, thereby, allowing the chassis manufacturer time to figure his maintenance cost on the body, since the contract will hold the chassis manufacturer responsible for the guaranteed maintenance of the chassis and body.

9. Tires. We have tried to standardize whenever possible on 10:00 x 20, 14 ply tires. Where dual tires are now used, there is a great effort by certain tire companies to have these tires replaced by the single, wide tread, aeroplane type tire. Some companies, especially those that are frequently off the road, are going to these units. A study of the advantages and disadvantages of this type of tire would be beneficial to the refuse handlers.

Summary

To summarize, the items to which research efforts could be applied are:

1. Study of equipment use - segregating refuse - weight - equipment cost - man power - ejector plate or dump body - aluminum bodies and frames - plastic material - all related to refuse truck use.

2. Engine study - size - HP - torque and formulas to justify agreed on size of engine, etc. - twin disc clutches - double reduction rear axles - lubrication - motor oils, etc. - transistorized ignition - realistic Preventative Maintenance Program - wide tread aeroplane type tires.

The above cover the major items on which research study could be made to help the municipalities and companies dealing with refuse. We feel that the City of Chicago and other large municipalities have been instrumental in getting lower prices on equipment they purchase, due to writing specifications which allow for competitive bidding. Anything the large municipalities could do to standardize their specifications (Would it be safe to say collectively?) would certainly help to reduce the price of equipment which is purchased by competitive bidding.

Residue Units

In the past few years, the major improvement in incineration that has had a pronounced effect on equipment, is the segregation of the residue. In a number of plants, the residues coming from the trough up into the hopper, are dumped on a vibrating screen or into a cylinder where all particles 1-inch or less in size, go into one hopper and larger pieces, which are mostly metal, go into another hopper. However, the hauling of fine residue is quite a problem. This residue is heavily saturated with water and weighs approximately 2,000-2,500 lbs. per cubic yard. Some of this water drains out; however, the greater percentage of it stays with the residue, and when 35 cubic yard trailers are used, this means they cannot be filled to capacity, since they will then be overweight. We, in the City of Chicago, are now working on a plan to utilize the ejector plate method.

A closed trailer of approximately 30 yard capacity with water-tight doors in the rear has been constructed. In front and on top, is an opening 6 feet square. The residue would drop into the trailer and when it is sufficiently filled, the door would close on top and the ejector plate would start compressing the load toward the outlet door in the rear. Two or three valve type outlets in the floor of the trailer, would allow the water to be pressed out of the load. This would do two things: 1) Get rid of the water, which would not have to be hauled away, and 2) Lighten the load substantially, even though you could get more residue in the trailer.

If the construction of this type of trailer is successful, it would eliminate any tell-tale drippage on the way to the landfill, which would mean we could operate on the expressways and toll-ways without any interference from authorities.

When one realizes that one cubic yard of water weighs around 1,700 lbs., it can be seen readily that the more water pressed out of the unit, the lighter the load will be.

Miscellaneous Items

Another field in which refuse trucks play an important part in the Northern areas is in the removal of snow by the use of snow plows mounted on the refuse trucks. There seem to be two types of chassis that are generally used for refuse trucks:

1. Tilt cab.

2. Conventional.

If manufacturers could come up with a standard "A" frame mounted on an extension of the chassis frame brought forward approximately 4"-6" (to allow for the mounting above and below the bumper) it would certainly decrease the cost of this equipment. Another item in connection with snow plows, is the use of plows which can be moved hydraulically, not only up and down, but also left and right. To do this while travelling down a street, road or highway, is impossible with our present type of PTO pump. If a PTO mounting could be devised that would allow for the unit to stay in gear, even when the driver would shift gears, it would certainly simplify the problems now encountered in trying to operate plows right and left while going down the street.

Where the incinerator and landfill are on the same property, off-the-road equipment can be utilized to an advantage. One example of this is the use of a unit similar to the Euclid 20 ton rear dump truck. Certain modifications must be made when this type of equipment is used in the landfill. For example, side panels must be used on the engine, the starter motor must be shielded, and a heavy duty alternator must be installed to give enough current to operate the lights during the entire night and not run down the battery. Using bulldozers in the landfill operation, certain items should be required, such as, moldboard high enough to protect the radiator from refuse sticking to it. Reverse blades on the engine, so that the engine heat is blown out of the compartment and not sucking in air from the front. This also prevents clogging of the radiator core.

Thus far this paper has dealt mostly with mobile equipment. There are a few related items should also be mentioned. In new incinerators where two or more cranes are used for bringing the refuse from the pit up to the charging hopper, a centralized control room is being advocated. There are number of advantages of this type of installation.

1. Decrease in number of operating employees.

2. More efficient use of the equipment by having centralized control.

3. Better operating conditions since this room can be airtight and properly ventilated and air-conditioned, if necessary.

4. Safety is also a big factor, since limit switches are now in use, which would prevent any collisions between various cranes or the sides of the pit.

Out in Whitemarsh, Pennsylvania, near Philadelphia, they have a vibrating conveyor for handling their refuse. This eliminates the use of cranes and also pits, since the refuse is dumped directly onto the vibrating conveyor and it then goes to the charging hopper.

The writer has tried to present some items which should be thought about in conjunction with added research. Also mentioned are various improvements which have been made in the past few years that we believe have been quite beneficial to the people in handling solid waste materials.

The help of Deputy Commissioner, T. C. Eppig, of the Department of Streets and Sanitation, City of Chicago, who gave of his experience and knowledge in connection with this paper, is gratefully acknowledged.

GENERAL DISCUSSION

MR. McCARTHY: With regard to maintenance of the forty trucks; are you specifying when that maintenance is to be done?

MR. KUEHN: Yes. The forty trucks, will go to the chassis manufacturer once a month, between 4:40 and 6:30 at night, and we expect to have them back the next morning at 7:30. We will allow one down time day a month per unit accumulative, for other repairs they may have to do. If they run out of down time accumulated, then they will be charged $15 a day for every truck that is inoperative. They have to give us towing service and repair service on the road, and if we have a road call to them and our truck is not back in operation within four hours, that is considered a lost day. To protect ourselves, at the end of the contract we are specifying, I don't know whether it is $150,000 or $250,000 in bonds for completion of the contract. There is also a clause which says they can never have more than five percent of the units in their shop at one time for more than two days. So that, let's say, by the end of the fifth year, they have accumulated 300 or 400 days, and we are without enough equipment in service. So far, every one of the manufacturers has approved the contract and are quite interested. In fact, we have received inquiries from several towns in the east that were quite interested.

CHAIRMAN XANTEN: Are you going to keep cost records on the other four units for comparison?

MR. KUEHN: Yes.

MR. ODELL: Have you looked into the use of propane gas? We are turning to it rather extensively. As a matter of fact -- this is my own personal opinion -- I believe our motor pool is jumping into it too rapidly, and I wonder if you or anyone here has had any kind of experience with it.

MR. KUEHN: Three years ago, our fleet was practically one hundred percent propane. Today we are about forty percent, and within the next two years we won't have any. In other words, as far as I am concerned, it has been a flop.

The manufacturers are taking gasoline engines and converting them to propane. As a result, you do not get the highest compression ratio that you need. You don't get the varying areas. The cam shafts are not right, and the over all picture has been very discouraging. The Willett Company in Chicago, one of the biggest rental truck operators, discontinued all their propane units.

MR. ODELL: That leads me to another question. I have been trying to sell our department on trying at least one diesel garbage truck. They argue that the smoke from the diesel will upset the taxpayers.

MR. KUEHN: We have 76 diesels in our fleet, which we are retiring now. Twenty-five of them are now in their eighth year. Of the 76, one had a complete engine overhaul at the end of six years, two had a cylinder, piston and a sleeve. Otherwise, they were never touched and their down time is the lowest of any of the units in the fleet. We are sold one hundred percent on them, and from the standpoint of the taxpayer, all you have to do is buy Almi-Mask. Your fuel supplier can get the product from the refinery. We kiddingly call it Channel Number 5. It is actually a chemical that gives you the scent of roses in the exhaust. Greyhound of Ohio used it because of the complaints they had in the City of Celveland, and it has been very successful.

CHAIRMAN XANTEN: Thank you very much, Mr. Kuehn for that interesting presentation.

Private Collections

Harold P. Jensen, President and Executive Director
Chicago and Suburban Refuse Disposal Association
Chicago, Illinois

The problems of the private refuse disposal industry in the Chicago area are similar to the problems of any private business anywhere, insofar as the factors usually referred to in a balance sheet or profit and loss statement or operating analysis prepared in accordance with the structure dictated by the rules of general accounting practice -- but to get to the heart of our problems you may have to re-think your usual definitions of "supply" and "demand."

The "supply" of waste material to be disposed of is ever-increasing. As our population increases, as our standard of living rises, as urban areas become more wide-spread, as the technical developments occur in industry, and as commerce grows in volume, the amount of refuse to be disposed of grows day by day. At the same time, the "demand" for such waste material remains static thus in our industry the "demand" is limited by the perimeter that we may designate as "means of disposal."

In the not-so-distant past, the business of picking up and disposing of garbage, industrial waste, ashes and similar refuse was a relatively simple one. You bought a horse-and-wagon, or a second-hand truck, you went door to door asking if they had any rubbish to get rid of, you loaded it onto your wagon by hand, and you either took it out into the country and burned it or you took it to a nearby lakefront or swamp and dumped it. As most of you probably know, much of Chicago's magnificent lakefront was filled in this way. Nowadays, of course, the cries of alarm that would greet any such open dumping of rubbish in any urban or scenic areas would be loud and long.

And we wouldn't have it any other way. The difference between today's refuse collection equipment and that of not so very many years ago is no longer news. Everybody knows that the horse and wagon has gone, and the open truck as a primary carrier of refuse seems destined to follow, although it will doubtless continue to be used for special applications.

Today's equipment is bright and shiny, or, at least, it is when it leaves the factory. If it is allowed to deteriorate and roam the streets in need of paint and washing, the image of the industry suffers. Realizing this, most owners of today's packers and containers keep them in excellent condition, with daily washing a matter of routine operation. Most haulers know that it is not only their own business that will suffer from a bad appearance put before the housewives and merchants who are their customers. The whole picture of refuse hauling as a modern industry, keyed to current needs and standards of sanitation and service can be seriously damaged.

We in the private refuse disposal industry are also residents of our communities. I for one don't want an open garbage dump next door to my home any more than you do. But new methods of sanitary landfill and incineration make open dumps not only old-fashioned but totally unnecessary.

We now have landfill sites in operation that are totally screened from their surrounding areas by trees, by walls, by built-up hills. The neighbors cannot smell the landfill operation, they cannot see the dump site, they are protected as far as possible from even seeing the trucks that bring the refuse to the site.

Sanitary landfill is much less expensive than other methods of refuse disposal, for example incineration, but it is not "free." In fact, the use of disposal sites is a major cost factor in the operation of any private refuse disposal business.

In 1955, the charge for the use of a typical dump site, per cubic yard of solid matter to be dumped, was 25 cents. Today it runs to as much as 85 cents in many areas -- an increase of 240 percent!

Other costs, too, have risen sharply. The cost of state truck licenses for typical trucks in suburban service have risen 456.4 percent, from $24 to $256. Partly this is because of increases in license fees. Partly it is due to the need for larger and heavier equipment to cope with the increasing amounts of refuse to be collected in our suburban areas. And costs in close-in, built-up areas have risen similarly.

Not only private enterprise has experienced the cost squeeze. Municipalities also face spiraling costs of refuse collection and disposal. And a number of municipalities have solved their problems to a great extent by turning to private enterprise to handle their rubbish collection and disposal needs.

The city of Waukegan, Illinois switched from municipal refuse collection to a private contract service. Waukegan Alderman, Milton Christensen said population growth made it impossible for the city to provide the service at a reasonable cost. By turning the problem over to a private contractor, Waukegan has saved an estimated $100,000 a year and has improved service. Waukegan pays the contractor out of its corporate fund and does not bill residents for the service. Practices vary, however.

Most municipal leaders agree privately that it is worthwhile to take such an emotion-charged and expensive service out of the realm of patronage and political "clout" and convert it into an efficient, private enterprise responsibility.

Rockford, Illinois, a city of 130,000 population, reports a saving of $75,000 a year, and Rockford officials can devote their time and energy to other pressing municipal problems.

Other cities in the Chicago area which have abandoned municipally operated garbage collection in the face of exhausted dumping facilities and increasing population include Elmhurst, Maywood, Western Springs and many other. Other communities allow individual residents to make their own arrangements with private contractors. Elsewhere in the country, there are large metropolitan areas such as Boston which have found private collection to be reliable and efficient.

Oak Park, Michigan has saved almost $53,000 in one year by changing from municipal to private contract refuse collection. (See Table.) The year in question is 1960-61 and the net savings amounted to almost $43,000. The absence of labor cost for personnel assigned to other public works but diverted to the sanitation department when extra help was necessary accounts for the difference.

One apparently simple solution to this problem of disposal costs would be to convert the waste matter from something that nobody wants and that nobody wants to pay for, into something that people want and that people will pay for. Research along these lines definitely is indicated.

It is true that certain types of solid waste make excellent fill. Swamps, quarries and other low areas that presently are worthless to humanity can be filled in a sanitary manner, topped with good soil, and converted into useful sites for parks, playgrounds, industrial developments and even suburban housing developments. This is already being done.

Toronto, Canada[1], is providing an excellent example of the benefits which may accrue to a community from well conducted sanitary landfill operations. The city's first landfill operation began in 1954 for the purpose of land reclamation after Hurricane Hazel struck the area leaving millions of dollars worth of damage. In one of the most devasted areas homes were swept from their foundations. The decision was made to rehabilitate this section, and the project was completed by 1958 when the land was raised 25 to 30 feet and contoured into a 36-acre park.

The metropolitan area is now creating more green areas from old swamps and other waste land. To date the city has completed three projects and is currently at work on three more. There are also plans which could lead to the creation of a five-mile-long park along the metropolitan waterfront of Lake Ontario.

Budgeted and Actual Collection Costs in Oak Park, Michigan, Showing Savings with Contract Collection

(Based on 1960-61 budget figures and wage scale)

A.	Force Account Pick-up	
	1. Direct Labor	$105,000.00
	2. Equipment Maintenance and Operations Cost (Based on three or more years D.P.W. records)	8,066.40
	3. Depreciation (Seven-year life-unbudgeted)	9,518.56
	4. Fringe Benefits	
	a. Retirement (3.21% of gross payroll)	3,370.50
	b. Social Security (3% of gross payroll)	3,150.00
	c. Sick leave (from past experience)	2,664.00
	d. Vacation & Holidays (per personnel rules)	5,569.28
	e. Life Insurance ($16.80 per person yearly)	252.00
	f. Workmen's Compensation (per statute)	3,087.00
		$140,677.74
B.	Private Contract Pick-up (low bid)	$ 87,868.56
C.	Gross Savings	
	Force Account Pick-up	$140,677.74
	Private Contract Pick-up	$ 87,868.56
	Gross Savings	$ 52,809.18
D.	Net Savings	
	Labor (Regular refuse-division employees)	$ 83,491.97
	(Additional help through grass season)	11,492.00
	Equipment Maintenance	8,066.40
	Depreciation	9,518.16
	Fringe Benefits (@ 17.23% of gross payroll)	18,092.78
		$130,661.31
	Less Cost of Private Contract Pick-up	87,868.56
	Net Savings	$ 42,792.75

These operations have been successful not only from the standpoint of permanent usefulness but have been financially self-sufficient as well. Although Metropolitan Toronto is responsible for the landfills and provides the areas for disposal, Metro does not collect refuse. Private contractors and the various municipalities that make up the metropolitan area are responsible for that. In fiscal 1960 landfill expenditures amounted to $315,636.64 while revenue for the same period came to $349,730.67. The facilities handled 191,583 loads during the year for an average disposal of 750 loads per day.

Despite dire predictions by certain researchers that the entire nation is going to run out of disposal sites within five, ten or 25 years (I've seen all three predictions), it is actually true that the Chicago area is not in fact running out of dump sites.

What we're running out of is conveniently-located dump sites that are acceptable to their surrounding communities. Longer and longer hauls to dump sites increase the costs of collecting and disposing of refuse, and necessarily thereby the charges for such services. And neighborhood prejudice against having dumps in the area makes it difficult to obtain legal permits for their use.

So what we need is public awareness that sanitary landfill sites need not be nuisances. What we need is more up-to-date licensing and policing policies for landfill and other disposal sites.

As is inevitable, the sanitation business has grown, and with its growth have come improvements in the equipment available to do the job as well as generally more stringent regulations in such matters as air and stream pollution. It is still estimated that a surprisingly high percentage of communities in the nation dispose of refuse in the old fashioned open dump, but it is certain that this incidence will decline in the future.

New incinerators are constructed with increasing attention to the suppression of air pollution, but disposal continues to be the most serious problem facing the private contractor (and many municipalities, as well). To be sure, some of the equipment manufactured within this four-year period has been designed to ease in some degree the contractor's disposal burden. Packers have come in ever larger sizes, and the introduction of the extra-large compaction trailers for long hauls to disposal grounds was a needed innovation that appears certain to remain.

Containers have continued to gain favor as an efficient method of collection as much as for the sake of amenity, and the recent development of a method for compacting the contents of stationary containers at industrial plants and other locations points up anew the emphasis now being placed on reducing the number of trips to dumps and incinerators by equipment that could be more profitably employed on regular or new routes.

The new concepts and modifications in equipment reflect not only the growth but the increasing complexity of the sanitation industry. Regulations, new and sometimes dangerous industrial wastes, these and more make life complicated for the private hauler, but they also give him new opportunities. Everywhere in the country enterprising businessmen are rising to these challenges and in so doing are not only helping themselves but also are helping to gain for the industry the respect it deserves.

Disposal is Governed by a Variety of Local Ordinances

Typical provisions in municipal ordinances for regulating the disposal or refuse are presented here as a guide to local officials in developing a new ordinance or revising an old one. Ordinances are not reproduced in their entirety because it is most improbable that any two cities are confronted with all of the same local conditions and therefore need all of the same provisions.

The ordinance provisions quoted have proved satisfactory in the city in which they are in force. They are not necessarily the best ones possible, and changing local conditions sometimes require changes in what once were satisfactory provisions.

The subjects ordinarily covered by disposal provisions of a refuse removal ordinance can be grouped under the following headings:

1. Definitions
2. Responsibility for refuse disposal
3. Management of disposal facilities
    a. Designation of authorized sites and facilities
    b. Who may use disposal sites
    c. Responsibility of site users
    d. Salvage
4. Control of kinds of refuse disposed of at municipal facilities
    a. Separation of refuse
    b. Hazardous refuse
    c. Dead animals
5. Control of private disposal sites

6. On-site disposal

7. Air pollution controls

8. Financing

9. Penalties for violations; severability

The terms used to designate different kinds and classes of refuse and technicalities should be defined in the ordinance. Standard definitions should be used in the ordinance, and in all published rules, notices, instructions, and publicity material. Some illustrations of definitions are:

> Garbage shall mean all putrescible animal or vegetable wastes resulting from the handling, preparation, cooking and consumption of food in any private dwelling house, multiple dwelling, hotel, restaurant, building, or institution.
>
> Rubbish shall mean all cardboard, plastic, metal, or glass food containers, waste paper, rags, sweepings, small pieces of wood, excelsior, rubber, leather, and similar waste materials that ordinarily accumulate around a home, business or industry. It shall not include garbage, ashes, bulk refuse, dead animals, hazardous refuse, industrial waste or building waste resulting from the operations of a contractor.
>
> Mixed refuse shall mean garbage and rubbish placed and stored together in a standard refuse container or in a substitute refuse container as required by this ordinance.
>
> Ashes shall mean the residue of the combustion of solid fuels.
>
> Bulk refuse shall mean discarded household furniture, beddings and mattresses, leaves, lawn cuttings, tree trimmings and hedge trimmings.
>
> Dead animals shall mean animals that have died naturally or have been accidentally killed. Animals or parts of animals from slaughter houses are not included in this category.
>
> Hazardous refuse shall mean any refuse the handling or disposal of which, in the opinion of the commissioner, would constitute a danger to city employees or to city property.
>
> Household waste shall mean mixed refuse, ashes and bulk refuse originating in and around private dwellings, multiple dwellings, fraternity houses, living quarters or dining facilities located in schools, colleges or universities.
>
> Institutional waste shall mean mixed refuse and ashes originating in and around tax exempt hospitals and public, charitable, philanthropic or religious institutions conducted for the benefit of the public or a recognized section of the public. Institutions not covered by the foregoing definition shall be considered commercial establishments.
>
> Commercial waste shall mean rubbish, mixed refuse, and ashes originating in and around commercial establishments, industrial establishments, hotels, restaurants, cafeterias and nonpublic institutions.
>
> Industrial waste shall mean any and all residue resulting directly from industrial or manufacturing operations. It shall not include waste originating from commercial operations of an industrial establishment, nor shall it include waste resulting from the commercial operations of persons, firms or corporations engaged in the construction of buildings, the repairing of streets and buildings, demolition or excavation. Residue or waste resulting from tree or landscaping services shall also be excluded.
>
> Building waste shall mean any and all refuse or residue resulting directly from building construction, reconstruction, repair, or demolition; from grading, shrubbing, or any other incidental work in connection with any premises; or from replacement of building equipment or appliances.

A licensed waste collector shall mean any person, firm, or corporation who obtains a license from the Commissioner of Public Works to collect or transport public or private household waste, institutional waste, industrial or commercial wastes, regardless of the place of origin, over the streets of the city.

Building debris shall mean any refuse or residue resulting from minor noncommercial repairs to a private dwelling made by the owner or occupant himself.

Designation of Authorized Disposal Sites and Facilities

The elimination of unauthorized and promiscuous disposal of refuse is basic to an effective sanitation program. It is customary, therefore, to restrict disposal as it is in certain cities.

Disposal of Refuse. No person shall throw, drop, or deposit, or cause to be thrown, dropped, or deposited on any premises or vacant property in the City any waste (including, but not limited to, garbage ashes, rubbish, building rubbish, dead animals, putrescible matter, and anything injurious to health), provided, however, that the prohibition contained in this paragraph shall not apply to the deposit of wastes not injurious to health on a public site where permission to make such a deposit is granted by the Sanitation Commission of the City, nor to the filling in or grading or property with earth, mud, ashes, and similar materials. . . .

We need research in these fields, too. How can we best spread the word that modern disposal practice eliminate the smells and other bad features of old-time garbage dumps? How can we convince the states, counties and municipalities that landfills can be permitted within reasonable distance of the source of refuse without annoyance to the neighbors? If you find the answers, please let me know.

Progress has been made in another direction. In areas where landfill costs have risen too fast to be absorbed or passed along to the customer, both municipal and private agencies have built incineration plants.

Now the costs of incinerating rubbish are approximately three times the costs of dumping or burying rubbish. And the costs of constructing efficient incinerators are astronomical. But some industry and public leaders feel they are necessary.

The value of incineration of course is in the reduction of the total volume or weight of the refuse to be incinerated. If you truck in 100 tons of solid waste and after incineration you still have 75 tons of waste, you haven't accomplished very much, and it's cost you a pretty penny to do it, too.

Unfortunately some incinerators merely remove the water from rubbish and hardly reduce the volume of waste at all. The more efficient models, however, can reduce waste to some 20 percent by volume. That is, for every 100 cubic yards of rubbish you put in, you take out 20 yards of residue.

Research has already begun on methods of profitably utilizing this residue.

Salvaged metal can, of course, be sold, depending on the current market value. Efficient operators retain their metal and other salvage until the demand is great enough to justify shipping costs. This means that incinerator plants need large areas to hold such material, and here we get back to the old problem of the neighbors not liking unsightly mounds of "garbage" in their back yard.

Residue other than metallic may also be utilized. At the plant of Incinerator, Inc., in suburban Stickney, a product called "Chempac" has been developed. It is described as a properly prepared and compacted mixture of incinerator scoria and lime, produced under controlled conditions and placed to specifications demanded by the particular usage.

The incinerator scoria not only reacts with the lime to produce strength, but it also provides the aggregate for the final product. The material is equivalent to graduations of sand from fine to coarse, with some gravel, although I am not an engineer and I may not be the most qualified person in the world to describe the product.

What is important is that it has been demonstrated as highly useful for parking lots, playgrounds, shopping centers and driveways. I understand they recommend that it be surfaced with asphaltic concrete.

What I have said about incinerator plants also applies to a great degree to household incinerators and garbage "disposals." The advantages of not having waste matter picked up by trucks must be weighed against the nuisance caused your neighbors.

We have found that backyard incinerators contribute to smog, and that the residue must still be picked up and somehow disposed of. And we have found that in-sink disposals, whether household or industrial, clog our sewer systems and force expensive expansion of the sanitary sewage system.

If your sewers back up in your basement, perhaps too many neighbors have installed disposals; if your neighborhood doesn't smell too good, perhaps too many neighbors are burning their own garbage.

Research might be indicated in the fundamental question of avoiding so much solid waste in the first place, but I rather doubt such research would lead to a successful conclusion. Modern packaging methods, pre-frozen foods, clear-view wrapping of vegetables, all makes for tastier-looking merchandise and presumably higher profits, but it also increases the amount of waste our trucks must pick up and remove. I strongly doubt that our problems are going to cause a halt to the trend to more pre-packaging, however.

Research might be indicated in the area of disposing of the waste matter while the collection truck is in motion. Some experiments have in fact already been made along these lines. But so far nobody has developed a mobile incinerator that is both practical and nuisance-free.

Perhaps we can use atomic piles to reduce solid waste into an insignificant volume of residue, and at the same time create energy, but again I am getting out of my field.

I hope that I have indicated some useful lines of research. I now leave the problems to the engineers among us.

Concurrent Panel Session

Treatment and Disposal of Solid Wastes

Group C

Treatment and Disposal of Solid Wastes

Abraham Michaels
Deputy Street Commissioner (Sanitation)
Philadelphia, Pennsylvania

The problem of refuse disposal has always plagued mankind. It exists in all environments, climates, and societies, and the intensity of the problem is related directly to the density of the population. The problem is easily solved in rural areas where there is ample space for composting, burying or burning of refuse directly by the producer. Obviously, the solution in urban areas is not so simple. History relates the debilitating effect that improper refuse disposal has had on cities throughout the years. The practice of dumping refuse in the city streets in the middle ages is recognized as a major reason for the spread of the bubonic plague.

Happily in the past century, and particularly since the beginning of the 20th Century, man has recognized the seriousness of the problem and has taken steps to provide sanitary refuse disposal. Here in the United States, an ever increasing percentage of all refuse produced in urban areas is disposed of by incineration and sanitary landfilling. The other major method of disposal, open dumping, with or without burning, is often conducted at sites reasonably far removed from populated areas, thereby reducing its unsanitary effect. A recent study by the New York State Office of Local Government revealed the following population-disposal method relationship for communities throughout that state:

Sanitary Landfills: 60 municipalities; 892,252 persons
Incinerators and Fills: 66 municipalities; 12,200,968 persons
Open Dumps or Private Disposal: 1,420 municipalities; 3,689,084

Assuming that private disposal is by open dumping, 78% of the population of New York State is served by incineration or sanitary landfilling, and the other 22% represents the smaller community averaging 2,600 people per municipality.

An appreciable amount of knowledge has been accumulated in the past 30 to 40 years in the field of refuse disposal, which knowledge helps considerably in our current daily operations. However, what we know today is woefully inadequate when viewed in the light of the task we know we will face tomorrow.

As mentioned earlier, the major problem exists in urban areas, and an examination of the changes that are now taking place in urban areas points up the magnitude of the refuse disposal problem of the future. Dr. Duane Lockard, Political Scientist of Princeton University in his book. "The Politics of State and Local Government" informs us that only 15% of the people in the United States lived in cities before the Civil War, and over two-thirds of the population live in urban areas at the present time. He forecasts an increase of 30 million urban dwellers by 1975, which is consistent with many estimates that the overall population in the United States will approximately double by the year 2,000. Dr. Lockard states that: "There is every reason to expect that the process of concentrating the population in the metropolitan areas will continue in the years ahead, as metropolitan areas continue to account for about three-fourths of the growth of the national population".

In addition to the above, the increasing affluence of our society is producing an increase in per capita production of refuse. An examination of recent statistics in my own city, one with a relatively stable population, shows an increase of 12% per capita of refuse produced in the last 6 years and an 18% per capita increase in the last 3 years. An evaluation of the above factors reveals that there are three major reasons for considerable immediate concern about the refuse disposal problem. These are:

1. Overall population growth
2. Growth of urban areas.
3. Increased per capita production of refuse.

It is further important to note that the bulk of urban growth is taking place in suburban areas, which aggravates the refuse disposal problem by eliminating many available land disposal sites close to the city. If the trends indicated above continue, it is reasonable to conclude that the acuteness of the refuse disposal problem can be defined as a geometric progression when related to time.

I have mentioned the three most popular methods of disposal in the United States; incineration, sanitary landfilling and open dumping. In addition to these, there are several other methods which should be discussed. These are composting, hog feeding, garbage grinding, salvage and reclamation, and dumping at sea. The above methods are briefly described as follows:

Incineration, as it is known today, is the process of reducing combustible waste to inert residue by high temperature burning.

Sanitary Landfilling is a process in which refuse is placed in trenches or on specific locations out in the open, then compacted, and covered periodically with inert material in a manner which is considered for the location of the fill.

Open Dumping is an uncontrolled method of disposing of refuse by dumping on the ground without treatment. This method is often supplemented by periodic burning, primarily to save dumping space.

Composting is the biochemical degradation of organic materials to a sanitary, nuisance-free, humus-like material. Modern scientific composting has been described as a rapid but partial decomposition of moist, solid, organic matter by the use of aerobic microorganisms under controlled conditions.

Hog Feeding is a conservation process in which the food waste or garbage portion of refuse is disposed of by feeding to hogs. It is important to note that health regulations throughout the country require that the garbage be heat treated prior to feeding.

Garbage Grinding is a method of uniformly reducing food waste or garbage and placing the reduced product in sewer systems. The reducing device may be a home sink grinder, or a large central grinder which serves industry or the community. It is noted that the ground garbage, which should pass through a sewage treatment plant must still be disposed of as sewage sludge after treatment.

Salvage and Reclamation as the name implies, is a refuse disposal process in which the refuse is segregated mechanically or by hand into various categories such as ferrous and non-ferrous metals, rags, cardboard, paper, glass, etc. The sorted refuse is then sold as waste or scrap.

Disposal at Sea is a sea dumping process which had been used extensively in the past, but which lost considerable popularity after the U. S. Supreme Court in 1933 outlawed dumping off the New Jersey shore by the City of New York.

In order to determine the areas of greatest need from a research standpoint, it is advisable to first note the current status of the science and art of refuse disposal, and then point out the problem areas.

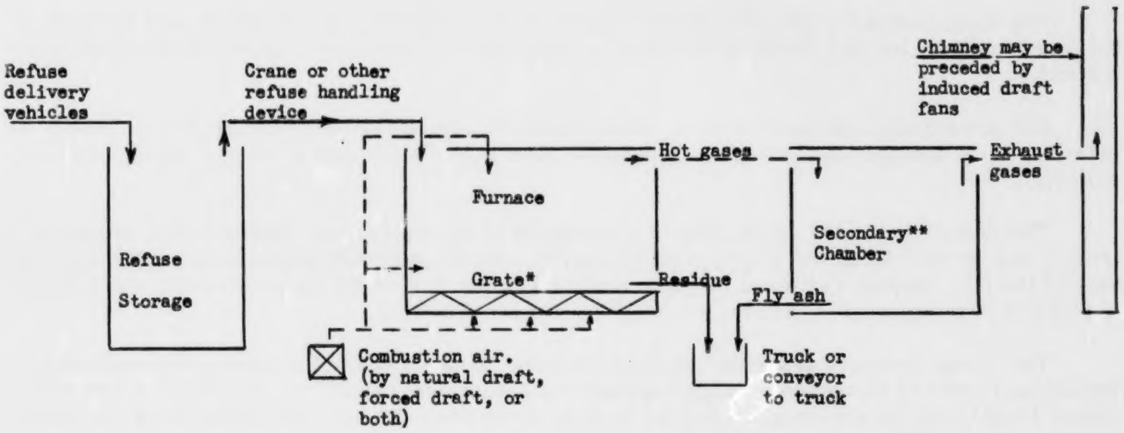
Incineration, as a method of municipal refuse disposal, started in England in the early 1870's. The first plant, as well as other early plants on the continent and in the United States, essentially burned swill or wet garbage at low temperatures, producing stack effluents with considerable amounts of smoke and odor. However, as early as 1885, an incinerator was designed with a secondary fire in the main flue which raised exhaust gas temperatures high enough to burn off hydrocarbons and moisture, thereby eliminating much of the stack effluent problem of the day. The secondary fire was produced by using auxiliary fuel.

In the early 1900's, furnaces were designed to produce high temperatures using auxiliary fuel in the furnace directly. Some of these furnaces were multi-cell units in which a mutual assistance process was used. This process generally required the segregation of refuse into wet and dry combustibles, with the dry combustibles being used to create sufficient heat to evaporate the moisture in the refuse placed in the wet cell.

As refuse characteristics change and as home coal furnaces are replaced with oil and gas burning units, and as living standards rise and people become more wasteful, we find incinerator furnace designs must also change. As man learns more about the epidemiological effect of air pollution and improper solid waste disposal, other elements of the incinerator plant must also change. What these changes should be to meet present and future public health and economic consideration is the basis for determining current research needs.

What does a modern municipal incinerator consist of today? This can be shown with the help of the following schematic diagram:

INCINERATOR SCHEMATIC DIAGRAM


Refuse delivery vehicles
Crane or other refuse handling device
Refuse Storage
Furnace
Grate*
Hot gases
Residue
Fly ash
Secondary** Chamber
Chimney may be preceded by induced draft fans
Exhaust gases
Combustion air. (by natural draft, forced draft, or both)
Truck or conveyor to truck

*Grate may be level, inclined, circular, rotating, fixed, movable or any combinations of these.

**Secondary chamber may be one or more enclosures used for combustion, fly ash settlement, gas cooling, fly ash collection, or a combination of these functions.

Using the schematic diagram as a guide, let us examine the problem areas in incineration. The heterogeneic mass, which is refuse, is generally delivered to the incinerator plant in the same condition it was in when discarded by the user, except for some slight crushing which might take place in the collection vehicle. In this condition, it occupies a considerable amount of space in a storage facility, contains varying quantities of moisture, and includes a considerable quantity of non-burnables such as glass, tin cans, etc. It might also include some extremely large and bulky items of refuse such as refrigerators, washing machines, bed springs, automobile parts, demolition waste, tree limbs, etc. Some of these items, by virtue of their size, weight, and chemical composition, cannot be placed in the conventional municipal refuse incinerator without causing considerable damage or retarding the normal operation of the furnace. If the non-burnables were to be removed, the large and bulky burnable items reduced in size, and all of the refuse prepared in a manner which would result in a more uniform type of material for handling and combustion, then conceivably current incinerator designs could be improved. So, the first function that we find in need of research effort is the handling and preparation of the refuse as it comes in to the incinerator.

Moving into the furnace itself, there have been several research studies conducted to determine the effect of the over-fire, under-fire air relationship and furnace configuration on combustion and air pollution characteristics. One noteworthy study is that which was conducted by the U.S.P.H.S. under the direction of Robert L. Stenburg entitled "Effect of Design and Fuel Moisture on Incinerator Effluents". This study was conducted to determine the effects of Fuel moisture content, the amount and distribution of combustion air, and the rate of burning on pollutant emissions from incinerators.

Unlike most other processes, there is no standard for determining the acceptability of the furnace end product, incinerator residue, and no method for measuring quality. With respect to the gaseous end product, there is considerable room for research there too. Besides the need for research on the process function of the incinerator, there is also a need to research the mechanical features of the plant. This is particularly true of the stoker, residue handling, refractory, and air pollution control devices.

Sanitary landfilling was started as a refuse disposal process in the 1930's when several large cities including New York and Fresno, California, decided to use heavy earth moving equipment to compact dumped refuse to conserve space. The process received its greatest impetus during the Second World War when the Army extensively adopted this method of disposal at camps and sites which were used for short periods of time.

The most common method of describing sanitary landfills is by the shape and location of the space filled, and the three most popular descriptive terms are: area, trench, and ramp method.

The area method of landfilling is one in which refuse is deposited in horizontal layers on relatively flat terrain and covered at regular intervals on top and over the sides with inert material.

The trench method of landfilling is accomplished by excavating land into the shape of a trench dug to any depth or length desired, and to a width generally determined by the working face of the fill. Refuse is placed in horizontal layers the full width of the trench; the top and working face is covered with inert material at regular intervals.

The ramp method, generally used in existing deep ravines of quarries, is conducted by spreading layers of refuse on an angle against the side of the ravine or quarry to a predetermined height; the height may be as much as 40 or 50 feet. Inert cover material is placed on the slope sides and top at regular intervals.

A landfill is often operated as a combination or modification of the above methods. Area landfills may be conducted in dry or wet areas such as: swampy, marshy, or tidal areas. Trench landfills must be operated in dry areas, however, trenches may be excavated to water table depths provided this is acceptable from a pollution standpoint. Ramp landfills are used in canyon and ravine sites, whether these be natural or man-made.

The problems encountered as a result of sanitary landfilling may be divided into two categories. The first might be described as operational, which would include public health considerations such as arthropod and rodent controls and land and water pollution, as well as the mechanical problems associated with materials handling. The second category relates to the useability of completed landfilled sites. Although a significant amount of research has already been conducted in the operational category, considerably more is needed, and the second category has barely been touched. It was difficult to provide a substantive answer to the following recent request from a metropolitan conservation authority: "We are particularly interested in determining such things as: the effects of sanitary land fills on ground water resources; the best subsequent uses for such areas; the problems related to building on former fill sites; the effects of sanitary land fill within river valleys and on flood plain lands; and any other problems such as; compaction and decomposition difficulties; methane gas generation; etc."

Some of the important research work in the operational category follows: (1) "Investigation of Leaching of a Sanitary Landfill" by the State Water Pollution Control Board in California published in 1954. (2) In 1961, Ralph Stone and Robert C. Merz reported the results of two studies involving landfill operations under test conditions in which moisture content, compaction, and aeration factors varied. This report is contained in the 1961 APWA Year Book. (3) Experiments on the water pollution effect of sanitary landfilling were conducted in England by The Technical Committee on the Experimental Disposal of House Refuse in Wet and Dry Pits. These experiments and their results are described in a publication entitled "Pollution of Water by Tipped Refuse", Ministry of Housing and Local Government, Her Majesty's Stationery Office, London. Notable results are: "(a) the amount of pollution in rainfall after percolating through controlled tip was considerable; (b) the rainfall underwent purification, however, during its subsequent passage through sand and gravel; and (c) there was considerable pollution arising through the tipping of refuse into water. Despite the efforts made to date in this area, there is still considerable need for further study of factors affecting settlement, fly emergence, and decomposition of refuse in sanitary landfills.

Since sanitary landfilling is a relatively new method of refuse disposal, and since most landfills were located in relatively isolated areas, little attention has been paid to the use of land developed as a result of sanitary landfilling. However, the growth of urban areas and the movement of people to the suburbs is rapidly changing this situation in two ways: (a) the landfill site, whether currently functioning or already completed, is in many instances no longer isolated and therefore potentially valuable; and (2) old quarry holes and swamp areas, which were considered useless because of their isolation, are now being looked upon as areas with potential for development. Often, clean fill material is not available and developers are interested in using refuse for this purpose. These new factors point up the need for study in the use of sanitary landfill sites.

Some experience information has been reported describing uses of completed sanitary landfill sites. One noteworthy article of this nature by C. A. Rogus entitled "Use of Completed Sanitary Landfill Sites" was presented at the 1959 APWA Congress. However, there is very little data available which would be useful to developers of existing sanitary landfills or those who are interested in using refuse for fill material. The research needs in this field are immediate.

Open dumping is not considered a sanitary method of disposal and, therefore, does not warrant future research.

The most controversial and over-sold, but potentially most desirable, method of refuse disposal is composting. It would be most desirable because composting produces a useful end product, it conserves material, its end product can be utilized to develop barren land for agricultural purposes, and it can enrich old, depleted soils. When used in conjunction with salvage and reclamation, composting, theoretically, could completely dispose of refuse without requiring the use of any fill space.

The composting process has been used by farmers for thousands of years, and is now used successfully as a refuse disposal method in several areas of the world. Unfortunately, despite considerable technical "know-how", and despite apparent sound financial backing and appreciable market development efforts, every attempt to compost municipal refuse on a large scale in the United States has failed.

Apparently, one of the important reasons for failure has been the inability of the producer to dispose of the end product, compost. The second reason for failure has been the inability of the investor to recognize the true cost of operating a compost plant. And, finally, there has been a tendency on the part of compost proponents to ignore the large volume of non-compostable refuse produced in the United States which must also be disposed of.

Historically, the first significant developments in composting as an engineered process took place in the 1920's. One of these processes, which originated in India and is known as the Indore process, consists of placing organic waste such as garbage, straw and leaves in alternate layers with night soil, sewage sludge, or animal manure into pits or trenches 2' or 3' deep, or piled on open ground to a height of about 5'. The pile is turned twice during a period of six months, and the drainage is utilized on the pile to keep the compost moist.

A second process was developed by Dr. Giovanni Beccari of Florence, Italy, in 1922. It combined an initial anaerobic fermentation with a final stage in which decomposition proceeds under partially aerobic conditions. The Beccari process was modified to produce what is known as a Verdier process, and this was further modified in 1931 by Jean Bordas, who attempted to eliminate the anerobic stage. In 1932, the first full scale composting plant in Europe was started in the Netherlands, using the van Mannen process, which is a modification of the Indore process.

Today, the most popular composting systems in use throughout the world are the Dano Biostabilizer System and the rasping system of windrow composting. The Dano System consists of a single slowly revolving cylinder that retains the compostable refuse for a period of from 1 to 5 days. The composting process is completed by windrowing after removal from the cylinder in a period of 2 to 4 weeks.

The rasping system consists of grinding the refuse before the composting process is started, and turning the compost piles during a 3 to 6 week period.

Several important research projects have been conducted in the field of composting here in the United States. Among these are the University of California Project which started in 1951 and which resulted in the publication of a report entitled "Reclamation of Municipal Refuse by Composting", published in June 1953, as Technical Bulletin No. 9. The purpose of the study was: (1) discern and evaluate the major factors involved in successful composting of solid organic wastes; (2) establish the optimum value and practical range of variations of each major factor; (3) outline the fundamentals of composting of municipal wastes under conditions obtained in California as well as most United States cities; (4) outline some of the design characteristics and economic factors involved in a composting plant. The conclusions reached as a result of this project are manifold, and are still an excellent starting point for future research projects.

A second significant study was conducted between 1953 and 1956 by a team of researchers of Michigan State University. This project consisted of both laboratory and field experiments on the composting of municipal wastes. The effects of temperatures, pH, moisture, and other variables of the composting process were studied and solutions to problems investigated by actually composting 4 to 5 tons of refuse per day from the City of East Lansing.

Other significant research projects were conducted by the USPHS in Savannah, Georgia and Chandler, Arizona.

Despite research efforts including those described above, and despite a number of attempts on the part of municipalities and private industry to use composting as a method of refuse disposal in the United States, success has eluded the developers. On the other hand, composting is currently gaining in popularity as a method of refuse disposal in many European, Asian and African nations, although in most of these areas it still accounts for only a small portion of the refuse disposal capacity.

For example, Japan has shown much interest in composting for some time now, and uses a number of plants for refuse disposal. However, a survey conducted in 1961 by the Japan Environment Sanitation Assn. of refuse disposal practices in the urban areas representing about 53% of the country's population revealed the following classification of disposal methods:

Incineration	9,260	tons/day
Dumping	10,300	"
Composting	916	"
Hog Feeding	273	"
Others	957	"
Total planned Collection	21,706	"
Self-disposal	4,526	"
Total	26,232	tons/day

The proponents and opponents of composting have a tendency to become emotional about the advantages and disadvantages of this "panacea" for the refuse problem in the United States. A sober, calm approach to the analyses of the problems associated with composting should be undertaken by uninvolved parties. Studies to determine the market value of compost produced by municipal refuse should be initiated. An examination of the conditions in foreign countries which resulted in the establishment of successful composting plants would be most helpful.

The practice of feeding food waste to hogs is, like composting, an ancient method of refuse disposal. Traditionally, farmers have kept hogs for "slopping" the left overs from the table, trimmings from the preparation of food, and other edibles. In Colonial times, pigs were turned loose in the streets in order to feed on the garbage which had been discarded by city residents. As cities grew, owners of small farms located near cities found it profitable to collect the garbage directly from residents to provide food for their livestock. Eventually, when cities recognized the health problems associated with refuse collection and disposal, storage and collection regulations were introduced and cities found it necessary to collect garbage with their own forces or contract with private individuals for this service.

Between 1953 and 1955, a virus disease of swine called Vesicular Exanthema prompted the USPHS and State Health Departments to enact regulations requiring the heat treatment of garbage before feeding to hogs. The cost of heat treatment, which is essentially exposing the garbage to live steam for a period of a half hour or more, coupled with the increase of labor costs involved in the collection of garbage, has resulted in a significant decrease in the amount of household garbage being used for the feeding of hogs. This condition is further aggravated by the continual growth of urban areas which tends to push the hog farmers further and further away from the areas of maximum garbage production, the big cities.

Despite these factors, the feeding of garbage to hogs is currently a significant method of refuse disposal. The APWA publication "Municipal Refuse Disposal" published in 1961, estimates that about 25% of the total quantity of garbage produced in the United States was used for hog feeding purposes.

Although hog feeding is now an important method of refuse disposal, we must recognize that changes, particularly from the increased use of home garbage grinders and the tendency toward more packaging of fresh fruits, vegetables and meats, will reduce the amount of garbage which will be disposed of by municipalities. Another factor which will tend to reduce the availability of garbage for hog feeding is the cost of collecting garbage separately from other refuse. Within the last two years, the City of Los Angeles has changed from separate to combined collection of rubbish and garbage, thereby reducing the amount of garbage available for hog feeding in the Southern California area. In view of these changes, it appears that hog feeding is destined to lose its popularity as a method of refuse disposal.

The disposal of food wastes by grinding, which process was introduced over 30 years ago, has been widely accepted in recent years. The process consists essentially of changing garbage into small particles and flushing it into sewers. The garbage is then carried to a sewage treatment plant where it is treated and finally disposed of. Eliminating garbage on the premises as it is produced is considered the ultimate in convenience and sanitation.

Although garbage usually represents less than 10% of the volume of refuse collected, it is the most troublesome portion of refuse from a public health standpoint. For this reason, garbage grinders, particularly the home grinder, is an important method of refuse disposal, the employment of which significantly affects the entire field of solid wastes sanitation as well as the water supply and sewage fields.

Garbage grinders are usually divided into three classes according to their use. Home grinders are the small units which are installed in kitchen sinks. Commercial and institutional grinders are large units used in restaurants, hospitals and food processing establishments. Municipal grinders are large units used to dispose of garbage collected by conventional means and taken to a central grinding station.

The extensive use of home garbage grinders would affect the solid waste sanitation service from the standpoint of on-site storage, collection frequency, and disposal requirements. It affects water supply by virtue of the fact that certain minimum water pressures are required to insure proper flushing although the quantity of water used for garbage grinding is not significant. Finally, the effect on sewerage systems is not significant in areas where sewers have reasonably adequate pitch. However, it could be detrimental where sewer installations are relatively flat.

The greatest effect of the use of garbage grinders is in the sewage treatment plant, where, assuming all garbage were ground at the point of origin and flushed through the sewage system, the suspended solids content may increase up to about 100%, the BOD may increase up to about

65%, and the amount of grit may increase by about 40%. These increases reflect in the additional solid load on sewage treatment facilities, which increase might require increases in sewage sludge produced, which might amount to as much as 100%, would result in the creation of a sludge disposal problem.

At the present time, the problem of sludge disposal is in some respects comparable to the problem of refuse disposal and the use of garbage grinders would aggravate this problem. Therefore, it is suggested that there is a need to research such processes as: (1) Incinerating sludge in combination with refuse; (2) Disposing of sludge with refuse in sanitary landfills; and (3) Disposing of sludge and refuse combined by composting.

Salvage and reclamation, as a method of refuse disposal, connotes the same image to the general public as does composting. It is a conservation process which allegedly would provide a municipality with a source of income as opposed to the costly methods of disposal which are generally used. The fallaciousness of this approach is apparent when one examines the experience in recent years. Such salvage operations as garbage reduction, which is a process used to extract fats from garbage, magnetic and hand-picking in refuse salvage plants, salvaging directly from the dumps and landfills, and dehydration of garbage, have been abandoned by many municipalities because of the high cost of labor, the uncertain and generally decreasing value of the salvaged products, and the frequently unsanitary nature of the process itself.

On the other hand, under certain particular conditions, some salvaging and reclamation has proven economical. For example, steam production from incineration has been used with some degree of success in a number of communities where the facility requiring the use of the steam is reasonably close to the incinerator, and where the cost of stand-by steam is low. The tin can portion of incinerator residue has proven to be useful in a copper precipitation process currently used extensively in the southwestern part of the country. And, incinerator residue itself is often used as fill material and is acceptable as cover material for sanitary landfills.

When one recognizes the acuteness of the problem of space availability for landfilling purposes, whether for disposal by the sanitary landfill method or for the disposal of incinerator residue and other non-combustible forms of refuse, the importance of salvage and reclamation as a method for ultimate disposal of refuse becomes apparent. The effort in research, however, should not be directed towards salvaged refuse as collected from the home, but rather towards using the end product of intermediate processes such as incineration and composting. For example, incinerator residue consists essentially of metal, glass, and inert clinkers and ash which may be useable in the manufacture of building products such as cinder block, concrete, and road building material.

Another major problem which is rapidly becoming most acute is that of the disposal of abandoned automobiles. This is primarily a problem of economics and is related to the cost of removing the combustible, valueless material from the salvagable metal. Until recently, the salvage process consisted of burning the cans out in the open and baling the metal that remained. However, open burning does cause air pollution and it is now against the law in most large cities.

New York University recently conducted a study of automobile disposal methods which pointed up the severity of the problem and described some incinerators which were designed specifically for this purpose. The paper which is included in the 1960 APWA Year Book is entitled "Incineration of Automobile Bodies and Bulky Waste Materials", and was written by E. R. Kaiser and J. Tolciss. Considering the magnitude of this special problem, it is suggested that this be considered as a project worthy of immediate attention.

For many years, starting around the early part of this century, disposal of refuse at sea was a method commonly practiced by coastal cities. However, in 1933, the U. S. Supreme Court upheld a ruling requiring that New York City cease this practice (New Jersey vs. City of New York, 290 U. S. 237 (1933)). Although a few other coastal cities continued to use the oceans for disposal, the Supreme Court decision reduced the importance of sea disposal as a method of refuse disposal. However, in view of the changes taking place in urban areas, and recognizing the increased cost of refuse disposal, it appears propitious to reexamine sea disposal as a refuse disposal method at this time.

One new concept to sea disposal which might be worthy of research is that of baling refuse prior to disposal. Baling might not only overcome the floatation problem, but might also considerably simplify handling, transportation, and shipping related to refuse hauling and disposal. In view of the unlimited space available for dumping in the world's oceans, this method should be studied extensively at this time.

Other methods of refuse disposal have been considered and discussed by people in all walks of life. I have heard that garbage has been converted into plastic, demolition wood has been converted into coke, and refuse has been chemically converted into a fertilizer. There will always be people seeking "Gold in Garbage", and perhaps research will eventually show how a valuable product can be produced from man's waste.

In the meantime, however, we must recognize that urban growth and affluence is rapidly creating a solid waste disposal problem that may bury us before any outside force can get around to doing it. Present refuse disposal methods are inadequate to cope with this problem, and we must improve these methods or develop new ones.

The needs are greatest in the fields of incineration, sanitary landfill, composting, salvage and reclamation, and sea disposal. The best way to acquire the knowledge needed to prevent serious public health problems from developing as a result of improper refuse disposal practices is to call upon agencies and organizations skilled in research to use their talents to study this problem. We ask that you help.

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Incineration

L. W. Bremser
Sanitary Engineer, Black and Veatch Consultants
Kansas City, Missouri

Incineration has reached its present state by a gradual process of growth. Thirty or so years ago, plants were built to burn a charge of refuse which was manually pulled down a fixed grate as it dried and burned. The charge was burned down and the residue was dumped and hauled away. The load factor was poor because time was lost in starting up and burning down each charge. The labor requirement for stoking was high and discharges of odorous black smoke occurred whenever the doors were opened to charge or remove the residue.

These plants were so offensive that many were abandoned in short order. In other places where incineration was essential because of the lack of sites in which to dump, the shortcomings were endured. Improvements came slowly. There was the mutual assistance principle in which several units were combined into one so that when one unit was charged or dumped, the heat from the others prevented too great a temperature drop. Then came moving grates operated mechanically.

Quantities of refuse have increased at a rate greater than the population growth. Our progressive economy with emphasis on pre-packaging of products has changed the nature of refuse. Many communities including some which abandoned plants years ago have exhausted dump sites and have had to return to incineration.

In the newer plants, methods of continuous feed have been devised to improve the load factor. Water-sealed conveyors have been adapted to remove the residue. Both of these factors have reduced periodic air pollution. Water sprays and mechanical collectors have been provided to reduce air pollution further.

However, even today there is no aspect of incineration which cannot stand a great deal of improvement and our purpose is to try to outline specific areas where improvement might be achieved.

First we should define what we are attempting to accomplish. The purpose of incineration is to reduce the volume of refuse to an economical minimum and to eliminate putrescibles so that the residue from the process may be disposed of in the same manner as any other clean fill material. This must be done without creating a nuisance and at minimum cost.

The ideal refuse disposal system from the producer's standpoint would provide a place to discard the refuse at the point of production with no containers or other gadgetry and with no further concern on the part of the producer. This seems far-fetched but I imagine so did the water carriage of sewage as a replacement for the honey-wagon. Everyday, there are more and more materials being handled in pipes by water, air and vacuum systems.

Gas-fired home incinerators have been developed which have a high temperature afterburner and which, when operating properly, will accomplish the purpose defined. They are not adaptable universally because they require a high-temperature flue which most homes don't have. Also, they require a rather large amount of natural gas for operation and the residue must be removed. As yet, they are not in the same category of practicality and convenience with kitchen garbage grinders. Further research and development is indicated to make these units as foolproof and reliable as possible but it is improbable that we can eliminate the need for central disposal facilities in the foreseeable future.

Very little is known about the material to be burned. Some research has been done on the composition of refuse produced in a few midwestern cities but more of such research is needed in other areas of the Country.

In considering central incineration, the first area of improvement concerns the delivery of refuse. Truck hauling in the usual 3 to 5 ton loads required a large number of deliveries to an incinerator of any size. Because the trucks normally start at about the same time, they reach the plant in groups, creating a traffic problem. This is particularly objectionable where residential streets must be used. Perhaps delivery by collection truck could be eliminated. I understand that New York's newest incinerator will use barges to transport the refuse and to serve as storage pits.

When the trucks reach the plant, they often must wait in line to be weighed. Automatic, high-speed weighing and data-processing equipment might be adapted to this function. Perhaps weight could be taken without the vehicle even having to stop. After weighing, the trucks must maneuver about in a tipping floor area and back into dumping position. With a large volume of traffic, this maneuvering is hazardous and the dumping is often a dusty, smelly operation. Improved plant arrangement or equipment might minimize or eliminate the necessary maneuvering. A better approach to dust and odor control might be to prevent its getting into the air originally rather than in having to remove it later. It might even be possible to handle the weighing, dumping and cleansing of the trucks on a mechanized, assembly line basis.

The storage pit has been considered necessary in order that refuse may be delivered during a hauling shift of 8 hours or so and burned over a 24-hour period. This improves the load factor on the plant and provides for more economical plant construction and operation. Storage of the refuse in an open pit also allows the crane operator to mix the refuse and achieve a more uniform fuel to feed into the furnace. The crane must be a high-speed, heavy duty unit. It handles a relatively light-weight, large-volume material and in a modern installation must move the material large distances both in the horizontal and vertical direction. Perhaps a method of storage other than the open pit could be developed or collection could be accomplished at night as well as during the daytime, if quieter collection equipment were used. Some method of charging which could be controlled automatically, perhaps by furnace temperature and without the need for a crane and the judgment of an operator, could be a worthwhile improvement. This would be complicated by the wide variation of refuse components which range from highly inflammable to noncombustible.

Development of methods of automatic charging will be made more difficult by the physical qualities of refuse. Refuse may mat and tangle and its components may be of all sizes and shapes, making it very difficult to handle mechanically. Perhaps pre-processing to achieve a physically more uniform material would be in order.

Modern incinerator designs require that the refuse be moved vertically a long distance in order to have gravity flow through the plant. Obviously, this is costly when we consider the tons involved. It might be possible to reduce this distance by improved furnace arrangement. If this difference in elevation is necessary, it would seem more practical to elevate the residue which is a relatively small portion of the original weight of refuse.

In the furnace itself, maintenance is a major problem. Even in the most efficiently operated plants, the maximum load factor obtainable is less than 90% because of routine maintenance outages. Incineration with its large changes in temperature and the practice in many plants of shutting down and cooling off for weekly cleanouts is very abusive service for refractories. Continuous feeding and removal of ash without cooling the furnace are designed into modern plants and positive seals are provided so that the amount and location of air entering the furnace is always under control. Automatic controls to feed the refuse and proportion the air properly to maintain temperatures as constant as possible would reduce refractory maintenance.

It is considered necessary to provide a certain amount of radiant refractory surface to store heat to dry and ignite refuse under adverse conditions. However, it would seem that much of the surface could be cooled in some manner to lengthen the refractory life. There has also been some question as to whether the entire enclosed volume is fully utilized. Studies could show the optimum arrangement of the combustion space.

In the United States there has been very little interest in utilization of waste heat. Because of the generally low cost of other fuels, even the promise of free fuel from incineration can be attractive only under certain conditions. Utilization of waste incinerator heat has been confined to the generation of steam and its use for heating or power generation. There may be some cases where it has been used to produce process steam. Because of the variations in quantity and quality of refuse it has been necessary to provide standby capacity using other fuels where a dependable supply of steam is required. Perhaps study would reveal other methods of utilizing the available heat. One possibility might be the use of the heat in the conversion of saline water to potable water. Using the waste heat in some manner would have the further advantage of reducing the temperature and volume of the exhaust gases. This would simplify the problem of handling them.

It has been noted that the rotary kiln type of incinerator has the ability to burn the refuse more completely than other types. This is supposedly because of the tumbling action which also entrains more solids into the gases. The hot inner surface of the kiln also assists in complete burning. Some tumbling or mixing of the refuse is probably necessary to expose new surfaces to the flames. Large amounts of underfire air also have been objectionable because of entrainment of additional solids into the gases. It would seem that the place to start on control of air pollution should be in the combustion phase by keeping solids entrainment to a minimum consistent with maximum burning of the refuse.

The continuously fed furnace with sealed charging opening and a sealed ash removal has the advantage over a batch system of providing a better load factor by eliminating the need for periodic burn-downs and by allowing better control of air. However, this can be a costly installation for a plant of small capacity. Study should be made of economical means of adapting the continuous flow principal to small plants. The continuous feed unit can be adapted to considerably more automation that has been used in the past in the form of automatic feed regulation, grate speed regulation and air volume regulation by temperature of other automatic control.

Drag conveyors discharging into trucks are generally used in modern plants for ash removal. Perhaps pre-processing of the refuse or processing of the residue would allow handling by pipeline directly to the ash disposal site and eliminate the need for hauling.

The air pollution problem has caused concern in recent years. Prior to this the only measures for reducing stack emissions were the provision of settling chambers with various types of baffling. Recently, plants have been using water to entrain fly ash. The attack on air pollution is only starting and we can expect more stringent regulations in the future. Mechanical fly ash collection has been used on only one incinerator plant to my knowledge and electrostatic precipitation has not been used in this country. In Europe, electrostatic precipitators are said to be relatively common. In the future, better control will have to be provided here and consideration will have to be given to electrostatic precipitation or even further treatment of gases. This points up the fact that reducing the volume and temperature of gases may become an important consideration in keeping the cost of stack gas treatment within reasonable limits.

In many places, stack emissions have already become a controlling factor in incinerator operation and practical monitering systems for operator guidance are needed today. Air pollution considerations have been limited largely to concern over the discharge of particulate matter. Little is known about gaseous pollutants which may be discharged by incinerators.

In summary, research is needed in all phases of incineration. We need to know the composition of the material to be burned and the gases to be treated and discharged.

Most of the points enumerated involve improvement of devices to eliminate labor required for incineration. Labor is a high percentage of the total cost and any steps toward mechanization and automation along with monitoring of results will reduce the labor required and the cost.

We need to take a fresh look at delivery, handling and storage of refuse. The human element should be eliminated in furnace charging. Pre-processing of refuse should be considered. The high cost and downtime for refractory maintenance must be reduced. There must be a completely new approach to waste heat use. Simplified ash removal should be developed. New and less costly methods for reduction of pollutants in the stack effluent need to be devised.

The ultimate goal will be the complete automation of large plants from the delivery and weighing of refuse entering the plant to the discharge of the residue at the disposal site. It will be years before such a goal is achieved but this should be the ultimate objective.

Incineration is a useful method for reduction of refuse volume but present practices are crude and costly. Past progress has been due largely to equipment manufacturers. It has been slow because of the small number of plants constructed. Incineration offers a prolific field for productive research and others beside the manufacturers must do it.

GENERAL DISCUSSION

CHAIRMAN MICHAELS: Thank you, Bill.

Gentlemen, the floor is yours. We would like questions from you, and we would like provocative questions, embarrassing if necessary, but let's get with it.

MR. MASSARO: I feel that our incinerator in Niagara Falls which was built in 1956, with the crane and pit operation, is one of the most modern. But there is a question whether or not direct dumping is most advantageous. As far as the refractories are concerned, the incinerator was built in 1956, and we relined the furnace last year. We have two furnaces capable of burning 240 tons in a 24-hour period. Now our biggest problem is seasonal variation. For example, at this time of the year, the refuse is wet and does not burn well. I would like to ask Mr. Bremser and Mr. Michaels whether or not this type of incinerator is the latest and best design. Some of the people in municipal government there think that direct charging might be better.

MR. BREMSER: The problem with designing a direct-charging incinerator is that you can only operate the plant when you are delivering the refuse, and therefore, if you deliver the refuse eight hours a day and wish to burn twenty-four, you can't do it. You would have to build a plant with three times the capacity.

CHAIRMAN MICHAELS: Do you mean that the plant should take the refuse directly from the truck into the furnace?

MR. MASSARO: Yes. In 1922 the city built an incinerator. This old incinerator was the type where the trucks used to drive in and dump onto a charging floor.

CHAIRMAN MICHAELS: Concerning the question of a bin and crane plant vs. a floor dump plant, we can consider the problem of handling wet refuse. With a pit and crane there is an opportunity to store dry material, or even to allow some of the wet stuff to drain, so that it is a little drier perhaps than refuse that is dumped directly from the truck. So from the standpoint of today's thinking, I would say that in your case, the bin and crane plant is superior. But as far as our thinking for tomorrow is concerned, maybe it isn't the best thing.

In the rainy season, the problem is how do you get good burning and maintain temperatures? We ask you researchers, what is the answer? How can we improve our design to handle these seasonal changes? Incidentally, this operating temperature of 1800 to 2000 degrees is a good average to maintain. Maybe this is an area to look for improvement. Perhaps higher burning temperatures might help solve the high moisture problem.

PROF. LUDINGTON: Is there any possibility of using waste heat to pre-dry?

CHAIRMAN MICHAELS: Yes, that it is possible. Some plants have been designed with preheaters which utilize some waste heat, but there have been many problems connected to that. I think that the whole question of preheating is one that is worthy of research.

MR. CALAME: Have any of the consulting engineers given any thought to utilizing the waste heat gases either through a counterflow system or in the storage bin?

MR. BREMSER: No, as far as I know.

COMMENT: In the last ten years, it seems, nobody has considered that refuse has been wet enough to justify the expense of equipment for preheating or pre-drying. Up to 1940, I don't think anybody built a plant without some kind of preheater. But they were very expensive to build and maintain and didn't work too well. As far as I know, they are not being considered these days.

PROF. LAMB: We have a clear economic balance here, that is, supplementary fuel vs. the cost of the preheaters. It is my understanding, that the use of supplementary fuel during periods when refuse was unusually wet probably would be cheaper than building and maintaining the preheating system.

MR. BREMSER: For the same reason Mr. Clark mentioned, even supplementary fuel is very seldom used today.

CHAIRMAN MICHAELS: I think you have to approach this from the standpoint of general conditions as they exist and specific conditions such as the wet season that we heard about. Generally, auxiliary fuel is not required. Actually, the problem is to provide cooling air in order to protect the refractories and the equipment. However, there are times when wet material does present a problem, and I don't think that there has been much thinking about handling this wet material in present-day design. But when you observe the residue that comes out of an incinerator, even the best of them, after a period of several days of rain, you will see a lot of unburned material in it.

MR. HARRINGTON, JR.: We know of several instances where there have been provisions for supplementary fueling, but these have been blocked off. They were very expensive and actually proved unnecessary.

PROF. SMITH: Have there been any studies made to determine whether there is any difference in the gaseous content when the fuel is burned wet or when it is relatively dry?

MR. BREMSER: As far as research on the stack effluent has gone so far, the only real concern has been for the particulate matter coming out of the stack, because that is what the air pollution regulations all stress. I have seen nothing at all on any other components of the stack effluent, and this in itself, sampling the particulate matter, is enough of a problem to start with.

PROF. SMITH: I have heard about some of the new packaging materials and wonder if there is any need to look into the possibility of noxious or poisonous gases coming from the consumption of some of these newer materials?

MR. BREMSER: Yes, I think it is very necessary.

PROF. LAMB: There is a parallel, I think, between this field of solid waste disposal and liquid waste disposal. If we look at history in the field of liquid waste disposal, we find most of the advances in treatment techniques which have been of practical significance, have been developed by relatively few people, in large municipalities.

For example, New York and Chicago, have been responsible for many developments which we use today. I would like to suggest that we not confine ourselves to the laboratory code or university work bench type of operation, but recognize the fact that much research could be done in larger municipalities. Perhaps joint studies with so-called research people and operating people would be appropriate.

CHAIRMAN MICHAELS: That is a good point, and I think we should point out some of the research projects that have been conducted in conjunction with municipalities. Here in Chicago, the Illinois Institute of Technology Research Institute has a contract with the U. S. Public Health Service, and APWA for the development of an incinerator stack sampler. This work is being done at a Chicago incinerator and with assistance from Chicago public works people. This joint approach is certainly desirable where conditions warrant it.

PROF. MOLOF: I think that possibly the incinerator is a case of the tail wagging the dog.

Engineers who design these systems, possibly because of economics, don't have time to really think through why they are going to build an incinerator for refuse disposal. I think incineration has to be set at a fixed design, and then go back into the preprocessing as mentioned earlier. In other words, in liquid waste disposal we have no choice of what is coming down, but in solid waste disposal, we certainly do. We can control what the people dispose of. We can do this by controlling the packaging that is issued. We were talking last night about what you would do with the paper on cans. Print on the cans. Don't use paper. I am sure since the people are going to have to pay for their refuse disposal, that they would encourage the manufacturers of packaging materials to cooperate, in order to simplify this problem. We should attack the whole problem that evolves from the packaging to the collection, to the preprocessing. Possibly the incinerator design can be fixed as in the kiln. I think this approach will give a better effect in the long run than concentrating on one single unit without considering the others.

MR. CLARKE: Nobody considers incineration as an isolated part of the work. It has to be a part of the overall refuse collection and disposal problem. Never forget that collection is on the average 75 percent of the total cost, so that increasing the disposal cost increases the overall cost less than a corresponding increase in the collection cost.

Many cities still have separate collections of combustible and non-combustible refuse. This is a method of preprocessing, but the present-day thinking is that the savings in disposal cost by incineration is more than offset by the additional cost of two separate collections. And so, incineration certainly should not be considered by itself. It has to be considered a part of the whole problem.

MR. HARRINGTON: I don't think any qualified engineer designs an incinerator without evaluating the total disposal problem. Also, you don't try to regulate the packaging industry and the entire refuse generating industry. I believe that technology becomes adapted to perform the service once the need is established. I am doubtful that you could set up a code which would effectively do what you are saying.

PROF. MOLOF: I think my position is more positive, and that the people would benefit. Take for example the detergents. The manufacturers in response to the waste disposal problem are changing their raw material to prevent the end problem. What I meant by preprocessing would include the idea of grinding. In other words, homogenizing paper and garbage so that they could be fed continuously. What is being done along this line?

MR. BREMSER: Nothing at the present time. This has not been considered essential because we can control the charging operation with a crane operator who mixes the material and feeds it from the receiving pit. But in order to go to any sort of an automatic charging, something must be done about the material to be charged.

CHAIRMAN MICHAELS: Wouldn't it be desirable to do some segregation -- not just shredding or homogenizing -- but perhaps remove the non-combustibles initially. Why carry them through the furnace? Why not take the glass and metal out before they get into the furnace, and take the uncombustible siftings out. Then perhaps you can blow the refuse into a furnace the way you would blow coal into a furnace and get rapid, complete combustion. Why not consider that approach and determine its feasibility through research?

PROF. MOLOF: By putting garbage into a kitchen grinder, you can reduce pickup time of the noncombustible material. I think we have to determine what is the best overall, and not just build incinerators.

PROF. SMITH: I wonder if a collection vehicle could be designed so that a collector could put combustibles in one end and non-combustibles in the other. The householder himself would do the sorting.

CHAIRMAN MICHAELS: This is the subject for discussion at another session, but the trend from the standpoint of continually improving public service is toward the collection of all refuse in one container. Since the householder looks for continual improvement in service, the idea of separation at the point of collection, I think, would run counter to the interest of the general public.

PROF; LUDINGTON: You mentioned wet refuse. What would be the percentage of moisture?

MR. BREMSER: Probably fifty percent moisture or maybe as much as sixty or seventy percent.

PROF. LUDINGTON: Since there are incinerators which handle sewage sludge, could something like this be used to take wet refuse?

MR. BREMSER: Those are generally a multiple hearth type where there is a counter flow, and the hot gases dry the material. Again, this type of unit would require preprocessing of the refuse into a form that could be handled in such a device.

CHAIRMAN MICHAELS: Of course, this is a seasonal or periodic problem. Would it be desirable to design an incinerator capable of handling wet material all the time, and use it for dry refuse too?

PROF. LUDINGTON: Are any cities mixing sewage and sludge with refuse for incineration?

MR. BREMSER: In Louisville sewage sludge is hauled to the refuse incinerator, mixed by a crane, and burned.

MR. HARRINGTON: This is also being done in Frederick, Maryland. The plant was designed in 1930. Raw sludge is conveyed to the top of a direct charging furnace. The purpose there is to provide enough refuse to support combustion and burn the sludge. It is not an elaborate sludge burner, but it does work.

CHAIRMAN MICHAELS: Have examinations of the residue been made to determine whether or not the sludge has been actually burned?

MR. HARRINGTON: Only visual. There is no evidence of sludge, but no work has been done on the stack effluent. Indications are that it is completely burned. Of course, that is an old fixed rate plant, where the sludge can just sit and burn out as long as there is enough refuse with it. I don't know how it would work on continuous flow or batch feeding where the charge is in the furnace for only a limited period of time.

PROF. SPEECE: I believe this is done in Connecticut, too. They have a primary plant, and the sludge is pre-dried so that it is just blown in like powdered coal. But isn't one of the advantages, of an incinerator that you can throw in anything.

MR. BREMSER: Yes. This has been the recent thinking in going to combined collection.

MR. HANEY: Are we entirely satisfied that we have all the information we need on time and temperature requirements for the destruction of odors? Has anyone investigated the stack gases for trace quantities of material? What time and what temperature does it take to destroy them, for instance? It seems to me that there is an area here that hasn't been worked on extensively. Clair Sawyer, I believe, published the most recent work on sewage sludge and the temperature requirements for the destruction of odors from the incineration of sewage sludge. Do we have enough information on this for incineration of refuse?

MR. BREMSER: I don't think we have had any problem with odors in recent years in incineration. The temperatures seem to be high enough to destroy anything along that line. As a matter of fact, the problem is to keep the temperature down, rather than to get it up high enough.

MR. HANEY: Do we have enough information on the time and temperature phenomenon -- the requirements for destruction of odor? Does it require ten seconds at 1500°, or a minute at 1000°? I think that would be a good project for investigation.

CHAIRMAN MICHAELS: Some work was done back in the early 1950's at the University of California, when they made three major refuse disposal studies, and I think the report does contain some information on chemical gas analysis. However, there have been sufficient changes in the characteristics of refuse since then to warrant a reexamination of this problem.

MR. HANEY: We have some pretty sophisticated instruments now for looking into gases.

PROF. PURDOM: We should reexamine the criteria used to judge incinerator stack effluent and perhaps bring them up to date. The criteria are going to be more severe in the future, both for particulate matter as well as gases. My impression is that the present standards on the particulate matter probably evolve from the combustion of fossil fuels, and may not be particularly applicable to incinerator operation for pollution control. Also, instead of evaluating stack effluents on the basis of percentage, we may have to look at the total quantity. In other words, a small incinerator emitting a small percentage of particulates might not be of much significance in the total air pollution problem, but a large incinerator performing at the same degree of efficiency might produce a loading that would be of great concern. Moreover, the pollutants may not be readily visible. These are changing conditions that should be investigated.

As an aside, you might be interested in some tests on domestic, gas-fired incinerators in Philadelphia that were made when I was with the City Health Department. These tests, made in conjunction with the local gas utility, were done in the laboratory and in the field. In general, they were not found to be as efficient as expected. And when you think about the possibility of putting these units in all of the homes, or even in a substantial number of homes, even though each unit might not contribute very much in the way of air pollution, collectively they could.

During the field tests, some units were installed in some homes in Philadelphia, and we were discouraged by complaints about operating problems that had nothing to do with air pollution, but might interfere with the units acceptability to the home owner.

PROF. HANES: Was garbage included in the charges put into these small homes units?

PROF. PURDOM: Yes, a sample charge was made up, including some garbage and carpet sweepings. A standard charge was used in the laboratory tests. Of course, in the field text it was just whatever the home owner put in there.

PROF. HANES: I was wondering if there were odors.

PROF. PURDOM: Carpet sweepings are one of the most difficult problems to handle, as well as some of the garbage.

PROF. SMITH: Not to belabor the point, I believe if I remember correctly in the exhaustive study done in Nashville in air pollution, they found that the increase in respiratory disease was more closely correlated with an increase in gases rather than particulate matter, so I think the gentleman's suggestion that there is a great need of sampling for this sort of thing is really one that needs some research. The air pollution people are probably doing this right now, but I do believe that sampling at the incinerator site or in the stack has to be done in the way of research.

PROF. BOUBEL: I think this might be a good idea. I know Andy Rose and his group at the Taft Center did some work about 1958 on incinerators. They have a rather complete and expensive model incinerator set up at the Task Center, and the last time I saw it, it was being used as a shelf for storage. I think this is a case of the squeaky wheel getting the oil, and Andy Rose's group has pretty well been swung over to the auto exhaust studies now. There were some papers beginning to come out on municipal incinerators, that looked like they had promise before this group was pulled off the study.

CHAIRMAN MICHAELS: Do you happen to know the names of these papers?

PROF. BOUBEL: The first one, I believe, came out about 1958, 1959 or 1960. They were putting out about one a year. That was Andy Rose's group. Stemberg was in on it. The original ones were concerned with model incinerators, and then they did some municipal incinerator work on various size plants around Cincinnati, I have a list of references at home I could probably find. Most of them were presented at the Air Pollution Control Association meetings.

CHAIRMAN MICHAELS: I believe one of these was reported in the Air Pollution Control Association Journal, April, 1960, and is entitled, "Effective Design in Fuel Moisture on

Incinerator Effluent." Work has been done, but just not enough, and as was pointed out here, the changes in refuse warrant additional work in order to determine what is happening to the gases coming out of the stacks.

MR. CALAME: Incineration depends on two things; time and temperature, and reduction of the raw material going in. Is there any reason why we cannot maintain a higher temperature in the furnace than we do now? In other words, we try to maintain an output temperature in the neighborhood of 1800 degrees. Is there any reason why we can't carry it to 2200 or 2400, and get a better reduction? Our primary concern is the reduction of the refuse. The incerator manufacturer can give you a higher BTU heat release per square foot of grate area if that can be carried on through.

MR. BREMSER: That is a matter of adapting the refractories to the unit. Perhaps this matter of cooling the refractory and using less radiant heat surface would adapt itself to this.

MR. CLARKE: In the first place, the BTU release per square foot of grate area with this type of fuel, I think, means little or nothing, because it is mostly volatile fuel that burns beyond the grate area. The temperature is primarily a refractory problem. I suppose there are more expensive refractories that would take higher temperatures.

COMMENT: I was thinking of reducing the required grate area, and reducing the cost of the overall installation.

CHAIRMAN MICHAELS: I think there is a relationship between grate area and heat release so that conceivably if you burn at higher temperatures, you could reduce grate size.

MR. CLARKE: The higher temperatures are beyond grate size. I don't think it has anything to do with burning on grates.

CHAIRMAN MICHAELS: Well, maybe this whole question of incinerator burning--temperature and its effects on the economics of incineration or design--is worth investigating. Theoretically, the higher the temperature, the smaller the air requirements, and maybe the smaller the size of the enclosure.

MR. CLARKE: I go along with that.

CHAIRMAN MICHAELS: If you can reduce the size of the enclosure, and reduce the grate size, you could save money.

MR. CLARKE: Not the grate.

CHAIRMAN MICHAELS: This has to be studied. But what happens after that may present different problems. You have to cool the gases in order to use presently available air pollution control devices. On the other hand, if control devices can be developed which operate at temperatures above 2000 degrees, and you can reduce the amount of fly ash, you might conceivable reduce the over-all size and cost of an incinerator to half of what it costs now. This is a worthwhile subject for research.

COMMENT: There has been no mention of the apartment-type of incinerator. Is there anyone here prepared to discuss the present state of the art regarding this type of incinerator and its possible future in the field of refuse disposal? The Public Housing Administration, for example, with their low-cost construction, are quite concerned about the future of this particular type of disposal device.

PROF. BOUBEL: The last issue of the Journal of the Air Pollution Control Association had a rather exhaustive article on single chamber, multiple chamber, and adaptations of these types of incinerators, which looked rather extensive. I do know that Arthur Bedlin, Air Pollution Control Commissioner of New York City, has said that one of his biggest air pollution control problems is the apartment house incinerators owned by the City of New York; but the City will not pay for air pollution control devices necessary to put on them.

MR. BLACK: As most of you probably know, the financing of apartment house construction is underwritten, in many cases, by the FHA. This is getting to be a problem in many cities, because the apartment houses must have some kind of refuse-handling facility. The traditional answer has been a flue feed incinerator. To produce something better and to get the financing group to change their ground rules, is going to take some doing. It is going to be very difficult to do anything after these places are built. They are going up all over the country.

CHAIRMAN MICHAELS: Isn't the Incinerator Institute of America interested in the design of apartment-house incinerators?

MR. CLARKE: They are more interested in industrial incinerators.

CHAIRMAN MICHAELS: Apparently this is another area where more research is needed. This is a special problem, something that is becoming more important as the population continues to explode.

MR. DOMINICK: As long as we are on the subject of air pollution, I am wondering about the operational value of Tepee burners. They seem to contribute a great deal to the air pollution wherever they are located. They have not been found to be too satisfactory even for burning papers and other combustibles. I am wondering about the experiences of others.

MR. VERHOEKS: We have a Tepee in Grand Rapids, (Michigan), which is highly successful. We burn paper, and also lumber and materials that come from urban renewal. It smokes a little bit, but the hotter it is, the better it burns. The difficulty is in controlling the temperature. At times she will cough up, and when you put some more into it, she will fog a little.

CHAIRMAN MICHAELS: It is better than open burning. Is that right?

MR. VERHOEKS: That is right. We concentrate everything in one spot. We can't afford a big incinerator. We have an open dump and sort of a landfill, and off to one side we bring in our lumber, paper, and other combustibles, and throw them into the Tepee and burn them. But we cannot burn logs, stumps, and trees. They must go into the landfill.

COMMENT: You can always turn the logs and stumps over to termites. They will take care of it in a period of time. But you can't burn garbage in this.

MR. VERHOEKS: We tried two loads, and it just smoldered.

MR. HARRINGTON: In Baltimore County, Maryland, we had experience with a private collector who had a Tepee. I agree with your earlier statement--it should not be called an incinerator, in my opinion. He was trying to burn mixed refuse, industrial wastes, and also urban renewal refuse and this sort of thing. The county authorities finally stopped this operation except for periodic special permission for burning a large tree, trimmings or things of this nature. They absolutely refused to allow him to burn refuse because of the air pollution problem. And I agree with you, it does smoke a little.

CHAIRMAN MICHAELS: We have had the same experience with one of these units near Philadelphia. The operator is west of us and the prevalent winds carry the smoke into the city. We have no control over him but, he is right next to a big redevelopment area, and our redevelopment people are tearing their hair out trying to get rid of him. It was even suggested that perhaps they can use redevelopment money to buy him out. I believe this is what he is waiting for.

MR. FARLEY: Referring to the Tepee Mr. Harrington mentioned, I remember when the contractor one time had all the household refuse we could possibly put into his burner by approximately 2:00 o'clock in the afternoon. They burned all night and all the next day, I believe. I left town, but I wasn't around when it happened. Two days later, I went down to see what he had raked out the back door of his Tepee incinerator. On the surface it was pretty good, but when the piles did cool and you could probe into them, it was pretty bad. I think he had to put practically everything into his land fill. Needless to say, the switchboard was loaded with complaints of air pollution. Odor and smoke were pretty heavy for the two days the operation was in process, so I think this ended the practicality of the Tepee burner in that section of the country.

MR. CLARKE: I agree that as far as municipal incinerators go, what is needed is a major development in handling the material and possibly grate design and things of that nature, especially air pollution abatement equipment, which can only be done by in-plant scale experiments, and probably then only by the larger cities. I don't want to downgrade the equipment manufacturers, but it has been New York and other cities that have done the development work, not the equipment manufacturers.

PROF. LAMB: I have the feeling that here we are trying to solve a problem without really knowing exactly what the problem is or how to define what we want to accomplish. There are certain health problems we want to overcome--certain nuisance problems. We want to reduce volumes. We may want to recover valuable materials. Until we can define what we want, we are going to be in a bad way to try to design or develop research tools to accomplish our objectives.

MR. HOPE: I am curious to know what responsibilities the state health agencies might have, for example, on the improvement of incinerators. What particular criteria do they apply? In view of the discussion that has transpired, this seems to be a local operation. Also, whose responsibility is it to develop devices that control the quality of stack gases? Are we going to leave this to the air polluters and let them develop control devices, or is this an integral part of the incinerator design? In my opinion, I think it is up to the incinerator people to devise whatever is necessary in the way of air pollution control devices to meet the air quality standards established by the air polluters, if they ever get around to establishing such standards.

CHAIRMAN MICHAELS: I think we are getting down to a basic question here--the real reasons why this conference was called. The refuse disposal field has evolved; it was not developed. It was not designed. It has grown up, like Topsy, so to speak. Sanitary land filling is an improvement over open dumping. Incineration is an improvement over open burning. Composting has yet to prove that it is an improvement over anything. This is the position we are in. Another basic question is, what is refuse? This is being discussed at another session, but we have to determine just what it is. As far as our group is concerned, it is important to devote some thinking to what should come out of the stack. What is acceptable, and how we are going to measure this? What should come out of the incinerator, and how are we going to measure that? These are the reasons for this meeting, and I think if we recognize that and can come up with research efforts directed towards solving these problems, we will have started in the right direction.

PROF. LUDINGTON: A considerable amount of research can be done in the laboratory. The question may be asked, "What piece of rubbish was causing the odors?" It would be impossible to determine this in a plant, but by doing it in a research laboratory where you can account for each item, you may find that floor sweepings are doing the damage. There is no reason why refractory studies can't be done in the laboratory. Instead of building six different incinerators and seeing which one lasts longer, this can be done in a laboratory.

CHAIRMAN MICHAELS: The point is that this thing can be approached from the standpoint of pure laboratory work as well as field work, which supplements laboratory research.

MEMBER: Can we specify what we want in the way of residue characteristics and stack characteristics. We ought to delineate what we want.

CHAIRMAN MICHAELS: We can give you general definitions. We can tell you we want a residue that will be acceptable from a health standpoint as a fill material, or we want a stack effluent that will not pollute the air or will be acceptable.

PROF. HANES: Why can't we start with maybe one of the first criteria that we consider in water pollution--the public health. This can be applied to both the stack effluent and the residue after incineration.

CHAIRMAN MICHAELS: There is your starting project: What are the health standards which would define acceptable residue and acceptable stack effluent?

PROF. LAMB: This raises an interesting question, "Do we want a highly-burned residue?" Maybe economically we would be much better off to get one not so well burned put it into a sanitary land fill.

MR. BLACK: Most incinerator operators hope that they can put the ash into a fill without covering it.

MR. BREMSER: If you have a area that is suitable for a sanitary land fill, you probably don't have any business building an incinerator in the first place.

PROF. LAMB: Except it may not be large enough. This may be a question of size.

CHAIRMAN MICHAELS: I would put it this way. Knowing what acceptable incinerator residue is, the operator then is in a position to determine whether or not he must cover this residue to provide a safe land fill, or whether he can discard it without covering--and incidentally, there are many incinerator residues today that are covered with more suitable material because they are not considered acceptable.

PROF. LUDINGTON: Instead of asking the Air Pollution Board to set the standards, wouldn't it be better to find out what we can attain, and then ask them if it is acceptable? In other words, let them prove that you are good or bad, rather than ask them what is good.

PROF. MOLOF: Putting economics aside, I think we have the hardware now to meet almost any air pollution standard. It is up to the state health people to tell us what they want.

CHAIRMAN MICHAELS: We can use hardware that has been developed for other purposes, but this is generally a very expensive way of doing it. If we can come up with equipment specifically designed for this use, I am sure it would be more economical than, say, air pollution devices used for power plants.

PROF. MOLOF: Perhaps effluent quality standards should be based on the capacity of the receiving air. But I don't think we have sufficient information to do this.

CHAIRMAN MICHAELS: This is why I said we can come up with definitions of what the effluent is, and then let the Health authorities set the standards. It is time now for a break.

Sanitary Landfills

Ralph J. Black
Chief, Solid Wastes Engineering Section
Special Engineering Services Branch
Division of Environmental Engineering and Food Protection
Public Health Service
U. S. Department of Health, Education and Welfare
Washington, D. C.

Regardless of whether incineration, composting, or some other volume reduction method is also utilized, cities are forced to dispose of a sizeable portion of their refuse on land. To be acceptable to the public, landfill operations must be first class operations, i.e., really sanitary landfills. Failing this, transfer and long hauls to disposal sites outside of the densely populated metropolitan area is the only prospect that can be expected to satisfy public demands. Not only must a landfill be operated without creating nuisances, but the entire project must be designed to result in some worthwhile plan for re-use of the land, or the public will not support the project.

Actually, there are four methods currently used to dispose of refuse on land. They are: 1) open dumping, 2) controlled burning dumping, 3) refuse filling, and 4) sanitary landfilling. Commonly reported operating cost ranges per ton are, respectively, $0.10 to 0.25, $0.25 to 0.50, $0.35 to 0.75, and $0.70 to 1.50. Unfortunately, there is more than a little confusion in the technical literature on this matter of nomenclature because of the tendency to label all landfilling operations as "sanitary landfills" in the vain hope that such labeling, by itself, will insure public acceptance of the operation.

Open dumping, as pointed out in the University of California study (1)*, "denotes merely the use of a reasonably well-defined area for the disposal of any or all of the separate classes of refuse without cover and usually with burning incidental thereto."

In controlled burning dumping, which is most common in the Southwest, refuse trucks are unloaded onto a prepared dirt bank, usually about twelve feet high with a slope of approximately forty degrees. The dump operator uses a hook to distribute any piles of refuse evenly, and then lights each load on the down wind edge. Noticeably less smoke is produced and a better volume reduction is achieved than when piles of refuse are burned. Usually, tin cans and ferrous metals are removed with a mobile crane equipped with an electro-magnet. The tin cans are processed and used by the copper mining industry. Although many of these controlled burning dumps are used in sparsely settled areas (2), some are being used in metropolitan areas such as San Diego.

At "refuse fills" there is a systematic and periodic operation conducted to compact and cover the refuse, on less than a daily basis. Operational techniques are the same as those conducted at sanitary landfills, with the exception that equipment is not used each day.

Sanitary landfilling was defined in the American Society of Civil Engineers (3) publication, Sanitary Landfill, as "a method of disposing of refuse on land without creating nuisances or hazards to public health or safety, by utilizing the principles of engineering to confine the refuse to the smallest practical area, to reduce it to the smallest practical volume, and to cover it with a layer of earth at the conclusion of each day's operation or at such more frequent intervals as may be necessary."

The use of sanitary landfills dates back to 1916 in England, where the process is called "controlled tipping." The process was adapted to American conditions at New York City, New York, and Fresno, California, in the 1930's, but only a handfull of communities experimented with the technique prior to World War II. Vincenz, who directed Fresno's early sanitary landfill efforts and coined the term "sanitary landfill", modified the method for the use of the Army. As pointed out by the American Public Works Association Committee on Refuse Disposal (4), "The successful use of the method by such cities as Fresno and New York, as well as the Army, influenced the adoption of it by many municipalities. By the end of 1945, almost 100 cities in the United States had adopted it and by the beginning of 1960 more than 1400 cities were reportedly using it."

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* Numbers in parenthesis ( ) refer to the appended references.

The technological base for designing and operating sanitary landfills has been reviewed by hardworking committees of both the American Public Works Association and the American Society of Civil Engineers. The publications that resulted -- APWA's Municipal Refuse Disposal (4) and ASCE's Sanitary Landfill (3) -- provide a great deal of useful information and references to the preceding experimental studies and current practices. Since these two reviews were completed, reports of further work have been published in a variety of publications. In order to make it easier to review this material, the staff of the Division of Environmental Engineering and Food Protection, Public Health Service, prepares annotated bibliographies on refuse collection and disposal. The growing interest, in all aspects of solid waste handling technology, is reflected by the increased number of items listed. For example, the 1958-1959 bibliography (5) lists 358 items, while the 1960-1961 bibliography (6) lists 627 items.

The relationships between refuse disposal operations and water pollution have been examined in some detail in England (7) and in Southern California by the California State Water Pollution Control Board under contractural arrangements. The California project was undertaken to collate, evaluate, and present the data on effects of refuse dumps on ground water quality. The published report (8), prepared by Engineering Science, Inc., also included a recommended program of specific research projects needed to fill gaps found to exist in the knowledge of the subject.

An on-site investigation of movement of gases produced from decomposing refuse is being conducted by Engineering Science, Inc. at Azusa, California. Professor Robert C. Merz of the University of Southern California is concurrently conducting a laboratory study to determine the quantity and quality of gas produced by the decomposition of a refuse comparable to that deposited within a sanitary landfill.

Two research projects on sanitary landfilling have been awarded by the Public Health Service. The title of the project, the name of the principal investigator, the institution, and a brief description of the scope of work follow.

Factors Controlling Utilization of Sanitary Landfill Sites

Mr. Robert C. Merz
Professor of Civil Engineering
University of Southern California
Los Angeles 7, California

Scope of work: To study the effects of physical and chemical phenomena on the rate of decomposition of organic matter in a sanitary landfill. The investigators will include practical field tests at a large disposal operation in the vicinity of Los Angeles. The field tests will consider the influence of moisture, soil admixture, depth of fill, type of soil, aeration, and temperature. Preliminary results of this work have been published by Stone and Merz (9).

Sanitary Landfill Investigation

Mr. Jerry C. Burchinal
Associate Professor
Department of Civil Engineering
West Virginia University
Morgantown, West Virginia

Scope of work: Bacteriological study of a sanitary landfill. The investigators will attempt to identify the groups and numbers of microorganisms which are active in aerobic and anaerobic refuse decomposition, to determine the rate of change in the environment of buried refuse from aerobic to anaerobic conditions, and the effect of high temperatures on *Escherichia coli* and *Aerobacter aerogenes* and whether nitrogen, potassium, or phosphorous is a limiting factor. They will make both chemical and bacteriological analyses of the landfill seepage, and its effect on streams and wells in the vicinity of the landfill.

Five areas of needed research in sanitary landfilling were listed in a special APWA report entitled *Solid Waste Research Needs* (10) which has been referred to by prior speakers. The *Report of the Committee on Environmental Health Problems to the Surgeon General* (11), commonly known as the "Gross Committee Report", also listed several areas of needed research relating to the operation of sanitary landfills. Of particular interest was the suggestion of developing methods of sealing pits so that abandoned quarries and other excavations could be used without danger of polluting ground waters.

A great deal of useful information has been developed during the gradual evolution of sanitary landfilling as a method of refuse disposal, but more specific information is needed to plan better and more economical operations for the future. Hopefully, attention devoted to research on sanitary landfilling will eventually provide the necessary leads to even more widespread use of this method.

GENERAL DISCUSSION

MR. JOHN C. WARD: When I was a graduate student, I worked at Tinker Air Force Base in Oklahoma City. They had a sanitary landfill, and used a bulldozer to compact the refuse, but they had a lot of trouble with fire. Quite often the trash on the bulldozer would be on fire and also the trash in the fill. I wonder if this is unusual, or is this commonplace?

MR. RALPH BLACK: A fire at a sanitary landfill indicates that there is something wrong with the operation. You can operate a fill without ever having a fire if you take reasonable precautions, obtain good compaction, and don't have your operator smoking on the job. I have yet to see a fire that could not have been prevented.

MR. WARD: What if somebody comes in with a hot load?

MR. BLACK: You may have a fire. Many fills will have someone on duty to see what is being deposited. The greatest trouble is when the equipment operator is not there all the time. Someone may dump a load, and when the equipment operator comes, he has a fire on his hands.

CHAIRMAN MICHAELS: It is good practice to have water on the site to wet down the refuse. This would tend to reduce the possibility of fire.

MR. BLACK: Yes, and in the studies that Professor Merz has conducted at the University of Southern California, they have markedly increased the compaction that they are able to achieve by adding water to the refuse. But in the arid west, this is expensive.

MR. ROBERT ANDERSON: If a fill is properly operated, there is going to be a very limited amount open at any one time. If you do get a fire, it is not going to be too hard to put out. A hot load can be dozed off to one side. The objective is to cover everything quickly.

CHAIRMAN MICHAELS: Knowing how some landfillers work, the fire might have been deliberate. This does happen.

PROF. A. H. MOLOF: Where can you get documentary evidence on the comparison between sanitary landfill and incineration?

MR. BLACK: There are chapters on both of these methods in the APWA Manual on Municipal Refuse Disposal. Also, in the ASCE Manual there is a section on operation costs, and in the back of it there is a list of operating costs for a number of fills.

CHAIRMAN MICHAELS: As a matter of fact, the APWA Manual devotes space to the question of determining what the best method of refuse disposal would be, and the procedures to follow in making this determination.

PROF. P. H. SMITH: How much of a problem in the landfill, is the anaerobic decomposition of organic material from the standpoint of gas material and so on?

MR. BLACK: Gas production has been described by Professor Walter Dunn at the University of Washington. He noted that gas production seems to be directly related to the moisture content of the fill, assuming that the constituents that are going into it are roughly comparable. With dry fills, and very low moisture content, little gas is produced. With the wet fills, the quantities of gas are increased.

PROF. SMITH: Climatic conditions and the seasons would have much to do with it.

MR. BLACK: Yes, and the temperatures in the fills.

QUESTION: What are the maintenance costs for a fill?

MR. BLACK: A reasonable range would be from around 80 cents to $1.50 a ton. The $1.00 per ton cost for the Los Angeles County Sanitation Districts fills include the cost of the land, access roads, weighing stations, administration -- everything. Since these are large operations, unit costs are less than most so they are able to do smaller operations.

CHAIRMAN MICHAELS: Whether or not there are maintenance problems depends upon many factors--the degree of compaction, the depth of the fill, the amount of decomposition that takes place, the type of cover material, and how well the job is laid out in the first place. Properly done, there should be no need for maintenance after the fill is completed.

COMMENT: We need to research different ways of transporting refuse. There are many fill sites that would be good for forty or fifty years, but they are too far out. I am thinking of transferring refuse from a central place to distant sites via, for example, pipeline or conveyor belts. Out west they are transporting different materials from mining operations and mills by conveyor belt. That doesn't mean you can convey a big refrigerator this way, but the bulk of the material, could be crushed, raked, shredded, and conveyed to the landfill. The cost of the system could be amortized over fifty years, and would probably be a cheap form of transportation. I think it is something to be looked into.

PROF. D. C. LUDINGTON: Mr. Black, were some of the homes shown in your slides built on fills?

MR. BLACK: No, the homes shown were not built on fill. In England some light buildings for park use have been built on a completed fill.

QUESTION: Has there been any work done or special consideration given to the construction of spread footings, and the planting of trees on landfill areas?

MR. BLACK: In New York in the late 40's, Mr. Elliason examined the foundation conditions on some of the landfills, and recommended the use of spread footings. Some structures have been built this way and some with piles. But there is insufficient information on the depth of the fill, the method of placement, type of compaction equipment, and other necessary items. As for trees, this depends strictly on the root depth. There are a number of landfills both in this country and in Europe that are used for agriculture (crop growing). Much depends on the root depth needed for a particular crop.

QUESTION: Is there danger to the tree from the gaseous formation?

MR. BLACK: I have never heard of such difficulty.

COMMENT: About four or five years ago, we built a landfill in a quarry. We filled it up, shaped it off nicely, and a welding factory was built on it. The city bought the building for a good price. They had it for about six months, and suddenly blue flame started coming up along the walls. We had to dig vents on all corners of the building, put up metal tile, put vents on there, and still today you can smell the gas coming out of the vent. In other words, the landfill looks nice from the street, but there is gas in it.

CHAIRMAN MICHAELS: Ralph, could you describe how the cover thickness affects fly emergence?

MR. BLACK: In laboratory tests conducted by the California State Department of Health, we started out with two feet of earth, which resulted in better than ninety percent emergence. Thickness was increased in increments to a total thickness of five feet, which still resulted in more than ninety percent fly emergency. This was uncompacted material, so then a compacted sandy loam with a binder was tried. The minimum thickness of compacted sandy loam that prevented fly emergence was 2-5/8 inches. This showed that if you are concerned with fly emergence, you should use cover material with a binder, and compact it well during the fly season.

CHAIRMAN MICHAELS: Is there any need for further research in the area of cover for landfill?

MR. BLACK: The part of this that I think needs looking into is not only the cover material itself, but also the differences due to climatic conditions.

CHAIRMAN MICHAELS: The need exists for research on sanitary landfill cover material to accommodate the variations due to location or changes in the seasons.

MR. HARVEY J. DOMINICK: I believe we essentially are conservative in recommending for or against a landfill site. Now theories have been expressed and the California Report substantiates some of them. There are possibilities that ground water contamination can and does occur, but there are many areas, especially in Northern Illinois, where we have limestone deposits, and we are concerned about possible pollution of ground water supply, not now but in the years to come. In Illinois we also sealed the Dunes, and we are considering the possibility of sealing some of the gravel pits, and seeing how it would work. It would be interesting to know if research has been done by other states or agencies in regard to preventing any possible contamination of the ground water supply.

This is a very extensive field that requires much investigation because our population is going to grow. And we are going to have to locate fills in areas that can be used without creating future problems.

MR. BLACK: You are probably thinking of sealants of one kind or another--plastic membranes or something to prevent water pollution problems. As far as I know, there hasn't been any investigation of this sort. The Britishers did report in one of their experiments that suitable compaction resulted in a resistance to water moving through the fill. So there might be some possibilities here, if you can actually place a dense enough fill so that any ground water would move through a different channel rather than through the fill. But there isn't enough enformation known on this point at the present time.

PROF. MOLOF: Regarding methane production, are there any design parameters on how to build a sanitary landfill to prevent methane gas production?

MR. BLACK: Not as far as I know.

PROF. MOLOF: In other words, if you build a sanitary landfill at the present time, you will not know if you are going to have gas.

MR. BLACK: You will have some. The question is how much, and where does it appear.

PROF. H. N. MYRICK: I think we ought to go back and look into the fundamental kinetics of the action that takes place. In other words, what is the biochemistry involved here? How can we best control this operation to our favor? I think it is time we looked at this as a unit operation.

CHAIRMAN MICHAELS: This has been explored in the past. That is, what conditions would cause decomposition; or conversely, what conditions would prevent it.

PROF. MYRICK: Do we want to encourage it, or is it something we do not want?

MR. BREMSER: In Los Angeles County the refuse will not decompose; and in Seattle, Washington, where it rains all the time, it is. This is not a choice we have to make.

CHAIRMAN MICHAELS: Do we have enough information now to say that we can pretty well determine whether or not decomposition will take place if a certain amount of moisture is there, or if the temperature conditions are within certain ranges? Or, is this worthy of further investigation?

MR. BLACK: Definitely, the latter. I don't think we have nearly enough information.

COMMENT: I might add something here. In a landfill near Chicago, after seven years, we excavated and found there was almost complete deterioration of the material, except for the cans, and even most of these were deteriorated. We found that we could use this excavated material after a short time, for cover. It makes a very fine cover. We also found that we could grow grass in it. It is an excellent soil additive. We have excavated material that has been buried as little as four years. We found considerable decomposition and a low moisture content.

MR. DOMINICK: Under what conditions was the fill initially started? Was it a pit with water or was it dry?

ANSWER: It was a section of old Lake Calumet.

MR. DOMINICK: That probably accounts for the rapid decomposition. Ordinarily in a canyon site in California, it would be the other way around.

COMMENT: You must realize that we have gone considerably above the ground level with our fill so we go down approximately ten to fifteen feet and find it all decomposed, but most of this is still above ground level.

COMMENT: In Charlottesville, Virginia, there is a landfill near a river bank, but it is all above water on a slope. They built up the area twelve feet deep in six years. Then they moved this aside and started over. They found rags and some of the heavier metals, but very few papers. They have a fair amount of rain there, but there is good drainage.

PROF. MOLOF: Is the objective to decompose the material, or is this not a consideration?

MR. BLACK: That would depend on what you are trying to do with the ground, and what your refuse disposal plans are in an area. I have seen some fills excavated after twenty years and very little decomposition had taken place. When the air hit them, they began decomposing.

PROF. MOLOF: Should we steer the process design, not only to dispose of the material immediately, but to create conditions favorable toward decomposition. This would be very definitely a good research point.

CHAIRMAN MICHAELS: This is in line with an earlier suggestion that we obtain some basic information regarding the conditions required to accomplish decomposition or to prevent it, depending upon what the user wants to do.

PROF. MOLOF: This is where I am confused. Are we interested in the decomposition or not?

MR. BLACK: Some are. Some aren't.

CHAIRMAN MICHAELS: If, as in the case of Southern California, a great deal of water is required to accomplish this, the decision might be to disregard this aspect as long as health considerations are met. These determinations should be made by the user.

MR. CHARLES S. GOODE: If there is sufficient stability for the use intended for an area, we do not need to be concerned about the rate of decomposition. You may get some subsidence, but if it isn't uneven, you can do most anything with the land. The primary problem is safety and draining off whatever noxious and flammable gases that might occur. However, there should be some way of labeling filled areas so that in the future people will know what they are getting into.

QUESTION: What is a required depth of cover. I have heard two feet being required.

MR. BLACK: The figure of two feet goes back to the work that was done in New York City in 1939, where it was recommended to control rodents (12). Actually, in the Los Angeles Area, the California State Health Department investigated some four years ago, and found that with a one foot cover there were fewer rodents of any kind including field mice and ground squirrels, in the active fill areas, than there were on the undisturbed native soil. But these were operations with good compaction, and actually if you don't have the face opened over night, there is going to be nothing to attract rodents of any kind.

MR. EDWARD SMITH: We have heard a lot of discussion on whether it is proper to build structures over landfills. In the City of Niagara Falls, there are three sanitary fill areas on which four-story apartment houses were built about ten or fifteen years ago. The local contractors used spread footings and reinforcing, and did an exceptional job in waterproofing the walls. I know there has been reluctance by some structural engineers to even think about this but I believe it is an important subject.

Right now in our city, a private developer is filling in an area in the Niagara River. He is planning a subdivision of about thirty or forty homes, in the price range of $25,000 to $50,000. As a matter of fact, he has two homes up there now, and is building a third one. I don't know whether or not these people are taking chances; but they are certainly investing in this type of operation.

CHAIRMAN MICHAELS: We shall continue this discussion this afternoon, when Mr. Goode will talk about "Utilization of Sanitary Landfill Areas".

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Utilization of Sanitary Landfill Sites

C. S. Goode
Assistant Director of Public Works
San Diego County, California

The sanitary fill method of refuse disposal has been an accepted and systematized procedure for less than thirty years. In that time, hundreds and perhaps thousands of acres of worthless and low value land have been improved by sanitary fills for extremely useful purposes. Most of us who have been in the refuse disposal business for sometime can enumerate the swamps, marshes, used-out gravel pits, and canyons that have been converted to parks, playgrounds, parking areas, and other useful facilities.

Even though we have these examples of the use of waste materials to create land for desirable improvements, we still encounter objections from property owners and real estate operators to the location of refuse disposal sites in areas which they own or control. To overcome these objections and convince the Planning Commissions and other local officials of the necessity for the location often requires the efforts of a super salesman. In the sales campaign, oratory isn't enough -- you must have facts. In most cases, you must have plans. Plans which merely create a fairly level area of higher elevation are usually not convincing. However, plans which show an ultimate desirable improvement using some imagination will make the selling job much easier. The opponents of a chosen location and the local officials will want to know why the refuse disposal site in this area is necessary. To answer these questions, you must have more facts. You must know haul distances and their costs, the relationship of the chosen site to other disposal areas, its capacity, and the estimated population which can be served over the useful life of the disposal facility.

In other words, it is difficult to sell any site unless you have a thought out and documented master plan. The creation of a master plan for a rapidly growing community is quite a problem. Although it is fairly simple to project the ultimate population growth on the basis of such things as topography and the availability of water, it is practically impossible to predict where and when increments of growth will occur. Attempts to make such predictions merely amount to a guessing game in which the professional planners try to outguess the land speculators and developers. Since real estate people use a different crystal ball than the planners and create housing where no housing is contemplated for a number of years, plans must be changed.

Although refuse disposal planning is not as involved as planning for sewerage, utilities, and roads, it is a continuing thing subject to periodic revision. Cooperation of cities and counties is a must. The coordination with departments representing city, county, and state planning, highways, recreation, and schools is extremely helpful.

We recently completed a refuse disposal plan for San Diego County which we hope will form the basis for planning for the next twenty years as we see it now. This plan calls for the operation of twenty-two refuse disposal sites by the county and three by the City of San Diego to accommodate the present 1.2 million population and ultimately provides for a population of twice that number.

Since the smog problem is not yet acute in the San Diego area, only five of our refuse disposal sites now are operated as sanitary landfills. The remainder are operated as controlled burning dumps. It also will be surprising to our neighbors to the north that we recently opened a large burning dump which accommodates the refuse from some 80,000 population. We have been pleased with the results after four months of operation at this site. We are also pleased to save the $60,000 annually which represents the difference in cost between this operation and a sanitary fill.

So that you may understand some of the whys and wherefores of our planning, let me briefly describe San Diego County. As you probably know, the county is quite large, having an area of 4,258 square miles with a coastline of approximately 70 miles and being 80 miles in depthat its deepest point. Except in the flood plains of its seven rivers, the terrain rises rather abruptly from the coastline to the foothills and then to two mountain ranges with maximum elevations of 7,000 feet. Beyond these high mountain ranges, the terrain drops off sharply to extensive, low desert areas to its eastern boundary. Concentration of population is primarily along a strip 15 miles wide bordering the coast with a few communities of moderate population on the plateaus and mesas in the mountain foothills. Of the total land area, only 52% is privately owned. The remainder is taken up by national forests, state parks, Indian reservations, and military installations. In many ways, this terrain is ideal for refuse disposal by sanitary landfills because of the great numbers of deep canyons eroded over the centuries by tributaries to the main rivers.

Water is our problem. With a rainfall of less than ten inches annually, all sources of water are important. For this reason, all usable ground water resources must be protected. Because of this, many refuse disposal sites which are desirable because of their location, topography, and soil structure have been rejected because of their possible effect on the ground water of the area.

The City and County of San Diego have cooperated excellently in all phases of refuse disposal. As evidence of this cooperation, the city and county jointly acquired a 250 acre disposal site outside the present city limits, and the city permitted the county to acquire another 114 acre site on surplus Navy land within the city.

Since all refuse disposal in the city and the county is conducted without charge, much city refuse flows to county disposal sites; and a smaller but significant amount of refuse flows from other areas into the city sites. Both the city and the county can be proud of the planned utilization of completed or partially completed sanitary fills. I would like to describe some of this utilization.

In the parks and recreation field, a number of improvements have been effected by planned utilization of sanitary fills.

Arizona Canyon in the city's beautiful and centrally located 1200 acre Balboa Park has been used for a sanitary fill for sometime. Even though this operation is located within several hundred feet of very desirable and expensive residential property, the operation has been conducted without complaint from the neighbors and will ultimately result in the creation of 40 acres of usable park land. Of this, 25 acres will be used for extension of an existing golf course. A 15 acre area is being developed for enlargement of the athletic fields of the park.

Another city sanitary fill, commonly called the Chollas area, has provided a 70 acre space on the completed fill for city Public Works headquarters and yard facilities. The eventual development of the total 150 acre Chollas area also will provide for a golf course.

A third sanitary fill conducted by the city on Navy property will eventually provide over 400 acres of usable land for the Miramar Naval Air Station.

Another example of city-county cooperation is an informal agreement between the county and city's park department for the development of a 30 acre city owned area in the Paradise Hills section for a neighborhood park. The city in this case has done the planning and will provide the large culvert pipe necessary to enclose a drainage channel through the park.

Although most county sanitary fills are located in canyons, one of the fills is in an area of very gently sloping land. The county was actually forced into buying this area after residents had established an illegal dump on the property. The location of this property was acceptable for a county park, but the uninteresting character of this 32 acre parcel presented a challenge to our Park Planner. We are quite proud that he has used some initiative in creating a plan which involves the forming of an ampitheatre in one portion and several other grading features which will result in a much more interesting and usable facility. It is also interesting to note that in the portion of this fill site, which has been completed, trees and shrubs have flourished on soil which in its original state was hard pressed to support a poor weed growth.

Portions of two county airfields have been utilized advantageously for sanitary landfills. In the case of the Palomar Airport, serving the north coastal area, the single runway was located on a ridge through the property. Other portions of the property contained one particularly deep canyon with a considerable portion of the property being much lower than the runway grade. The master plan for the ultimate development of the airfield calls for development of the canyon and a considerable portion of the low lying areas by sanitary fills. On the portion of the fill completed at this time, a number of T hangars have already been built. As areas are completed, they will be made available for construction of other hangars, shops, and aircraft tiedown mats. We do not feel that problems will be encountered with this light construction and anticipate the creation of 20 acres of high value rental land within the next five years.

At another county airfield, a two-pronged canyon in the corner of the property has been utilized for the past eight years as a sanitary fill. This fill which now accommodates the refuse from 145,000 population will have a maximum depth of 130 feet when completed early in 1964. In our planning, we have reserved a shelf of undisturbed soil on the hillside bordering the fill which should be capable of supporting any type of building construction. Over 10 acres of filled area at approximately the same elevation as the shelf of natural soil can provide for landscaping and parking. We feel that this property should accommodate an exclusive resort hotel. Our planning in this case has not been entirely up in the clouds as several hotel operators in the area have expressed their interest in this site. This is understandable because the view is tremendous, looking over a broad expanse of El Cajon Valley to the panorama of foothills and high mountains to the east. We are certain that our speculation in this case will prove profitable.

The county's experience in cooperating with school districts may be somewhat unique. In most of San Diego County, school districts have a difficult time finding school sites that provide sufficient level ground for playgrounds and athletic fields in addition to the necessary buildings. Usually, the school sites require considerable grading. Knowing this, we talked to several school districts suggesting they cooperate with the county so that playgrounds and athletic fields could be created from canyons or depressed areas by utilization as sanitary fills and thus save the school district considerable grading cost. It was by accident that one school district found that an existing sanitary fill on leased property would admirably suit their purpose for a school in that area. The real estate broker who had been trying to evict the county was greatly surprised at the proposition submitted by the school district and to find that the sanitary fill had actually created a saleable property out of a fairly useless canyon.

Following the completion of this first sanitary fill for the school district, a second site was bought, having a much deeper canyon, with the understanding that the canyon would be filled by the county to an agreed elevation for use as athletic fields. It is estimated that this fill can be completed within the next two years and in time for the proposed school construction.

Similar to experiences in other areas, the county recently completed a sanitary fill, the location of which was strongly opposed prior to and during the first stages of operation. However, since its completion, the improvement has been lauded by residents of the area and officials of the adjoining community. This area was locally known as the "Duck Pond" but had long ago ceased to be a pond and became an unsightly mudhole. A number of factors favored filling the "Duck Pond." Among these were its frontage on an important thoroughfare and its proximity to county owned property formerly used as a quarry from which the desirable granite had been removed leaving areas of undesirable disintegrated material. By filling the "Duck Pond" and utilizing the disintegrated granite from the adjoining county property, two very desirable and high value industrial properties have been formed.

The desirability of this operation is attested to by the petition of all but one of the abutting property owners asking that the county continue the operation to the upper reaches of the canyon tributaries of the "Duck Pond" property. Both of the properties created by the "Duck Pond" operation are surplus to the county's needs and should be sold for the commercial and industrial uses for which they are presently zoned.

However, there is a question in our minds as to the conditions, in addition to those imposed by the Uniform Building Code, that should be required in case of private development of the sanitary fill site. We feel that the county should be safe and protect the prospective buyer from any hazards which might occur from the formation of methane gas in the fill. However, we have no criteria for ventilation of slabs on grade and know of none that have been proposed as the result of any reputable investigations. Although this is an isolated case, there probably will be many similar instances in which specific safeguards should be provided for the construction of buildings over sanitary fills.

Very few visitors to San Diego's incomparable Mission Bay Aquatic Park with its multi-million dollar development of hotels, marinas, and recreational facilities are aware that 115 acres of the original muckland were developed by sanitary fill. This area in which the fill was completed three years ago now supports beautiful tropical vegetation, roads, and parking areas. Many other portions of this beautiful development could have been accomplished by sanitary fill saving the city the cost of expensive hydraulic fills if the complete development of the park could have been delayed.

In a short talk of this kind, very few phases of refuse disposal and utilization of sanitary landfills can be touched upon. However, let me again emphasize the necessity for the creation and constant revision of a refuse disposal plan. In other words, try to keep ahead of the developers. Although most sanitary fill sites in the past few years have served a need for development as parks or recreational facilities, it does not follow that in the future sanitary fills will be located in areas where parks are needed. So, other uses for completed sanitary fills must be found.

Even in the development of parks, we feel that some imagination should be used so that the grades of the completed fill will correspond to the planned utilization of the area. I hope that the sketchy examples of sanitary fill utilization in San Diego City and County may be of benefit to others. Our experiences are not entirely unique, but we do feel that we have had a diversity of planning and have used a little foresight and imagination.

We feel that continued research is needed to determine what happens to refuse in sanitary fills over a number of years under various climatic conditions. The work of Professor Merz and Ralph Stone in recent investigations has been quite helpful. This type of investigation should be continued. We also feel that definite guides are necessary for the construction of buildings over sanitary fills. It seems that such guides should be made available to Building Inspection Departments throughout the country. Additional research and wide dissemination of this type of information is certainly needed.

GENERAL DISCUSSION

MR. DOMINICK: Who controls the burnings:

MR. GOODE: The county fire marshall. Whoever does the burning gets a burning permit, which tells you under what conditions you may burn. Burning is usually limited to the period between 6:00 p.m. and 6:00 a.m. and on days on which the relative humidity is sufficiently high.

COMMENT: Have you any gas problem?

MR. GOODE: No. We use very little water because it is scarce. I doubt whether much methane is produced because with a precipitation as low as ours, there is just not enough moisture.

QUESTION: Would you say then, based upon your experience, that you could safely tell a potential land buyer that there would be no gassing problem?

MR. GOODE: No, I don't think so. We should be absolutely certain. I would hate to sell a piece of property to a person and then have him find out there is gas. There have been rainfalls in the area of twenty to twenty-two inches, and if we have one of those years, I would like to know what happens. This hasn't occurred for many years.

CHAIRMAN MICHAELS: Perhaps we could learn the answers through some research. A few test holes in a fill might provide much information--more, perhaps, than laboratory experiments.

MR. GOODE: In one 170-foot-deep fill we achieved densities exceeding 3000 pounds per cubic yard. It varies, of course, but to me, that is tremendous.

COMMENT: The City of Chicago filled, about twenty-five or thirty years ago, to a depth of about 20 feet, a flooded area that was made into a small park. Two years ago, we had a great deal of snow--about 64 inches--and there was an explosion in a sewer serving the homes alongside the park. So after about twenty years, there was considerable methane gas in the fill. It seems that the snow cover, which amounted to about two feet, closed off the natural openings through which the gas escaped, and consequently the gas was forced into the sewers.

CHAIRMAN MICHAELS: This points up the need for better understanding of what takes place in sanitary landfilld. You have to recognize that this method of refuse disposal is still relatively new; so that, even though it is practiced extensively, here is a case where it took twenty-five years for a dangerous condition to develop. We should be in a position to warn people about what they are apt to get if they buy property that has been filled this way.

PROF. SMITH: I am a microbiologist, interested in this gas production aspect. We know the waste is going to form Salmonella and things of this sort. Here is a problem that couldbe looked at microbiologically. What occurs over a period of time to the microbiological relationships in the landfill? This could not be done in any one section of the country, of course, because of the differences in climate.

PROF. GAUDY: Mr. Goode, when you cut into your landfills, is there much evidence of decomposition?

MR. GOODE: Within three or four years, we find very little decomposition.

PROF. GAUDY: This brings up a very important point. We have heard how some people cut into their landfills and, in five to six years, find the material decomposed. But in three or four years, you find very little decomposition. Then we hear comments on how the problem in one geographical location is going to be different from the problem in another one. I would propose here that we know quite a bit about landfill right now. If we would go back and survey all the people who have been operating the landfills, and who have had these different experiences we would come up with some valuable information.

We have one landfill that is wet and aerobic. The decomposition is rapid. Another is anaerobic and possibly wet. This gives a different result. We have other landfills under dry conditions, with different results. The information is there. Why not assemble it before we go experimenting? This would give us something on which to base our thinking.

CHAIRMAN MICHAELS: You might say that the starting point for a research project would be to collect available information, analyze it, and then determine what you are going to do.

MR. HARRINGTON: There is one other thing to take in to account, the content of the refuse. In Baltimore, in the early forties, they started a sanitary landfill. The garbage content of the refuse was high, and if you dig back into those old cells you will find what appears to be digested refuse. It has been compared with incinerator residue and things of this nature. Yet, in the recent fills, established in the early fifties, you can still find newsprint that is readible. It is thought that this is due to the lack of garbageI think you are going to see the effect of this, as time goes on.

CHAIRMAN MICHAELS: Also, in checking the records on the types of material placed in these landfills, you will find that there is a scarcity of information. So, even though you can learn what is happening in a number of landfills throughout the country, you would not know the conditions that prevailed at the time that this material was placed in the landfill.

MR. GOODE: We need long-range investigations.

COMMENT: But, the character of refuse is changing so fast that a long range investigation isn't going to help much. By the time you finish the investigation, the character of the refuse will be different. I think we should look far ahead, but if you are going to wait years and years for results, you are defeating your purpose.

PROF. MOLOF: There is enough basic science and enough similarity in any process that we will be able to predict what we want to do with this material. If you say that in 5 years you want to construct a certain type of building, we should be able to say that you have to do this and this in your operation of the landfill. In other words, we will bring sanitary landfill into a treatment process, not just a disposal method. With the fantastic background of the many fields contributing to this problem, I think we will be able to pull something out of this, and develop within the next several years some good design parameters.

PROF. BURCHINAL: We at the University of West Virginia are doing a study on the ecology of sanitary landfills, and are finding a definite lack of information. One thing we don't know is whether the same bacteria are active in different parts of the country. Also, regarding gas production, we are getting results that are not in agreement with the gas production they were getting from fills in California. Apparently this is also affected by the character of the refuse.

QUESTION: Is anyone ready to lay the ground rules for collecting this information?

PROF. MOLOF: A problem as complex as this would need some time to think it out.

CHAIRMAN MICHAELS: A gentleman here, from one of the equipment manufacturing companies, said something about the effect of different types of equipment on compaction. Would you care to tell us more about this?

MR. WILLIAMSON: Sometimes we are asked to recommend types of equipment. But from the foregoing discussion we can conclude that this would be determined by the degree of compaction desired, which in turn would depend on the ultimate use of that particular landfill. I think that this could be one of the parts of a study program. What is the density needed to get the desired results--the digestion, the decomposition or the lack of such?

CHAIRMAN MICHAELS: Conversely, what effect does density have on decomposition?

MR. HARRINGTON: You said that frequently you are asked to advise. It is my own personal belief that it is best to get the assistance of a professional, either public or private, to evaluate the entire situation.

CHAIRMAN MICHAELS: That is a good reply. Now you, as a professional, feel equipped at the present time to come up with a suitable answer to the question, What kind of equipment should I use for a landfill.

MR. HARRINGTON: I think the professional is as qualified to evaluate the over-all picture and suggest equipment as anyone else.

CHAIRMAN MICHAELS: But does anyone have a measure which would be useful in determining what equipment should be used for a particular landfill, or is this something that should be studied?

MR. BLACK: We do have some information, but it is in general terms. Again, we need more specific information. This is usually dictated primarily on the job at a particular site, and depends upon the kind of material you have to work with, the kind of equipment you inherit, and the kind of budget you have.

CHAIRMAN MICHAELS: Assuming that you could acquire the equipment that would do the best job, is it necessary to learn more about various types of equipment to come up with some answers?

MR. COOKE: Equipment is not the only factor that determines density. In a 300-foot fill, the material on the bottom is naturally going to be compacted. Also, if your method of operation is such that you have heavily loaded scrapers or trucks running over the fill after you place it, you will get compaction which has nothing to do with your regular compaction which has nothing to do with your regular placing equipment.

MR. DOMINICK: Maybe I am misinterpreting this, but I think you are making a mistake by neglecting the information that many of the heavy equipment companies can furnish. Whether you ask private or public professional people, does not matter. You can use them both. It is wrong to assume that government officials are the only conveyors of knowledge in the sanitary equipment field.

There is also a new item in the equipment line which you Public Health people should be interested in. The operators at sanitary landfills are subject to a lot of harmful dust. We have provided air conditioned hoods for this.

MR. HARRINGTON: Please don't get the idea that we want to exclude information gathered by the equipment manufacturer. It is of great value, and has its place in the over-all picture.

QUESTION: Can incinerator residue be dumped in an area without being a public hazard to health? And is the dust that comes out of the stack detrimental to health?

CHAIRMAN MICHAELS: We have both of these listed as research projects.

MR. COOKE: Mr. Goode, do you have anything to substantiate that the dust is detrimental to the health of the operator? I have been told by our Public Health authorities that they have found nothing.

MR. GOODE: We have had some respiratory diseases. Los Angeles County has found the same thing, and has equipped its people.

MR. COOKE: We know that fills are very dusty, and uncomfortable, and anything you can do to make your operator more comfortable will be for your benefit. But can you pin this down and say that it is detrimental to health?

MR. GOODE: We have a peculiar disease, called valley fever. One of our folks got it and he's been debilitated for quite some time. I don't know where he got it. But all of the operators are anxious to avoid it.

CHAIRMAN MICHAELS: This is sort of a medical problem now. I think it is a little far afield.

Let me ask a question of the sanitary landfill experts. We just vaguely touched on this question of construction on landfill sites. Do we know enough about the stability of landfills--about the capability of supporting loads--or do we have to investigate this further?

MR. GOODE: I think not. This is an engineering problem met every day in different types of material. To determine such things as differential settlement, and the bearing value at a certain point is simple.

CHAIRMAN MICHAELS: You think then, that something like a foundation analysis is all that is required for landfills?

MR. GOODE: I think the local building codes will specify the types of foundations that are required.

CHAIRMAN MICHAELS: Does everybody who is familiar with this agree that we don't have to research this area? Let's pose the question a different way. Based on your experience with the construction of buildings on old landfill sites, except for this problem of gas, do you think that anything has developed which would indicate that there is need for additional information?

MR. GOODE: I think there is room for research on the formation of gas and the way to safeguard any construction over fills in a number of varying conditions.

CHAIRMAN MICHAELS: Perhaps as part of an over-all survey that was suggested, information pertaining to problems that may have come up in old fills should be obtained.

MR. COOKE: I think it is a well established fact that you are not expected to build on all of these fills. They can be used for park areas.

MR. GOODE: Can we assume that we are always going to need parks? As far as our area is concerned, we are going to get caught up on parks one of these days, just by utilizing sanitary fills. Of course, they can be used as school yards, and we are hunting for other uses.

MR. COOKE: Have you ever started a sanitary landfill in a canyon with the hope of building on it?

MR. GOODE: Yes. We have built airfield structures. They are very light, and I have no doubt about them. As long as the fill remains under public ownership, I am not concerned. But when you pass this area over to private ownership, what are these people going to do with it? We don't have a good answer.

CHAIRMAN MICHAELS: Maybe some of the research will produce the answers, particularly how to design a fill so that it can be stabilized and subsequently utilized.

MR. GOODE: I think the idea that we need to accumulate all available information, is good.

PROF. GAUDY: An important analogy here in some respects is the oxidation pond and the so-called lagoon. We can dig a hole and operate it as a biological treatment process; we can promote biological degradation. A landfill can be a land reclamation project, or an actual treatment process. We would like to use the landfill, have it do its job, push it aside, use it over again. This is where it becomes a treatment process, not just a land reclamation process.

CHAIRMAN MICHAELS: I think we have covered the subject quite thoroughly, and I would like to thank Mr. Goode for his fine paper and discussion.

Composting of City Refuse

Ir. W. A. G. Weststrate
Managing Director, V. A. M. (Refuse Disposal Company)
Amsterdam, The Netherlands

Composting of city refuse may serve two objectives. It may be stated that either the principal aim is to remove city refuse, or one may start from the assumption that agriculture and horticulture need organic manure and that city refuse can be utilized for the preparation thereof. Of course it is impossible to disconnect the one from the other, but it makes a difference what is considered to be the primary object: refuse disposal or the manufacture of manure.

In the Netherlands, composting has in the first place been applied because there was a demand for compost on the part of agriculture. In the past decade, however, there has been an increasing tendency to apply composting as a means of getting rid of city refuse, since the municipal authorities have realized that refuse compost can yield good prices. Thus it happened that several compost plants have been built in my country in the last few years. Remarkably enough, the sale of compost was not adversely influenced by the markedly increased production. On account of the larger number of compost plants, compost became more widely known. In addition, the number of purposes for which this manure is used also increased.

Yet it goes without saying that it is risky to prepare compost for the sole purpose of getting rid of the refuse; it should be ascertained beforehand whether there is a market for refuse compost.

In the Netherlands, compost prepared from city refuse and night-soil has already been used for many centuries. This compost should not be compared with what is nowadays being prepared in modern compost plants. But for a few exceptions, no night-soil is added to it nowadays, which is a great advantage from a hygienic point of view. (Night-soil, as a matter of fact, is not the most important component for the value of the compost as manure). When chemical fertilizers came into use, at the beginning of this century, the interest taken in compost disappeared. Chemical fertilizers yielded better results and could be more easily administered. The old method of preparing compost by hand was no longer applied. The municipalities proceeded to use dumping and incineration. Until the tide turned. About 1930, agriculturists in the province of Drenthe, a province containing poor sandy soil and peat soil, requested the city The Hague (then 450,000 inhabitants) to send its refuse to the province of Drenthe, where it could serve as a raw material for compost, instead of being incinerated. In compliance with this request, a company was established, which built a fully mechanized compost plant, where compost could be made from municipal refuse of The Hague.

This was a good start, for mainly as a result of this procedure the exploitation and sale were mainly entrusted to exports in the field of agriculture. Much experience was gained with this compost plant in the province of Drenthe and after World War II, fourteen more compost plants of four different types were built. A few more are under construction and being planned.

This development enabled us to acquire extensive knowledge regarding techniques, fermentation processes, and applications in agriculture and horticulture. A great deal of this knowledge was acquired through the trial and error method, but many experiments were also made, especially with respect to applications as manure.

Four Methods of Composting

This following is a brief description of each of the four systems:

1. The Van Maanen system.

The big plant in the province of Drenthe was built in 1931 in accordance with the plans of Mr. Van Maanen, whose name is connected with this system: It is a simple and inexpensive system, suitable for large quantities.

The city refuse is heaped in big long rows and moistened. It is fermented by means of bacteria and molds. Through the process of fermentation the substances are broken up and disintegrated and it is obvious that this is an inexpensive procedure. The bacteria are doing their work free of charge and they need not be fed, because they have enough to feed themselves on.

After bacterial decomposition, which takes about six months, only an after-treatment is necessary to remove or shred the hard and non-fermented parts. The use of electricity and wear and tear on the machinery are comparatively small.

However, there is one drawback attached to the Van Maanen system: it can only be carried out in remote places not in close proximity to a city, because the big heaps of refuse are not only unsightly, but produce an odor as well.

It is likely that it will be possible to counteract the disagreeable smell to a considerable extent or almost entirely, but this is not certain, as it still has to be proved in practice. It is also necessary to combat flies and rats, but in a moderate climate as prevails in the Netherlands, this presents but few difficulties.

2. The Rasping System

The city refuse is disintegrated in a big rasping machine. As is known, it is ground through a screen which is partly covered with steel pine that have the effect of a rasp. Now and then those substances which do not are drained off through a special aperture.

Through the disintegration the refuse loses its disagreeable qualities, it has no odor during the process of fermentation (or it may have some odor) and it does not attract flies or rats. In addition, the fermentation of disintegrated refuse goes quicker and more evenly than that of non-disintegrated refuse. On account of these favorable factors, a rasping plant may be situated in close proximity to a town, e.g. in an industrial quarter of the town. As the disintegration is done by machine, however, this system is considerably more expensive than the Van Maanen system.

The hard particles which should not be left in the compost are removed from before the process of fermentation takes place. The rasping system was developed in the Netherlands in 1951, and in 1952 a pilot plant was constructed at Schiedam (80,000 inhabitants).

3. The Dano System

The old or classic Dano-system dates back to shortly before World War II. It consisted of two drums, one big drum rotating slowly for the mixing of the refuse and one drum rotating more quickly for grinding the substances.

The grinding drum consisted of steel bars with slits between them, and was enveloped by a large rotating screen. The particles trickling out through the slits and holes were fermented into compost. Of course this compost also needed to be cleansed of glass splinters but this step was often omitted for the sake of simplicity.

After 1960 the Dano factory came out with a new machine: the biostabilizor. Instead of the two drums one very big drum is used, which rotates slowly. The refuse remains in this drum for some days, if possible five days. Air is blown through, the compost is moistened and, as it were, turned over through the rotating movement. As a result of this, fermentation sets in quickly, so that a fine dark-colored product is obtained after a few days. This is screened, and the coarse part, which does not pass through the screen is thrown away, or it may circulate again, but in that case the drum must be made even bigger. The fine half-decomposed refuse which passes through the screen has to be cleared of splinters etc. and has to be fermented still further. This system is attractive for refuse which is easily fermented but the yield is not high. The residue is considerable. A disadvantage is that for large quantities the drums become too big.

4. The Hammermill System

This method does not need much explaining. The hammermill spins quickly in shredding refuse, whereas the rasping machine turns slowly in serving the same purpose. The remaining steps are similar to those of the rasping system. Now the question remains: which machine yields the best results? Perhaps the advocates of the hammermills would say: there is nevertheless a fundamental difference, because by means of a rasp it is impossible to disintegrate the refuse altogether, there is always a residue, whereas the powerful hammermills are able to disintegrate practically all of the refuse. The advocates of the hammermill system are only right if they succeed in making a mill which not only accomplishes this in practice, but also without preliminary sorting and in such a way that a usable compost, free from undesirable particles, is obtained.

Technical Operations

The technical operations consist of:

1. the disintegration of municipal refuse, and
2. the purification of the product from parts which are hard, sharp or which, for other reasons, have a disturbing effect.

We have already dealt with disintegration. When the disintegration is not effected by bacteria and molds, it can be effected by shredding in hammermills, through rasps, or by crushing in the quickly rotating drum of Dano type installations.

The purification required to clear the compost from all kinds of components which should be removed presents more difficulties than the disintegration of the refuse. These impurities may be:

1. splinters of glass and pottery
2. pieces of coal and clinkers
3. iron
4. non-ferrous metals
5. pieces of rubber, leather etc.
6. nylon
7. hard plastic particles
8. plastic foil.

Of course it would be possible to get rid of all these parts if it were possible to screen the compost on a sieve with holes of 3/8" or smaller, but that is not easy. Therefore, other methods are being supplied.

The heavy components can be pulverized, insofar as they are breakable (glass, pottery, clinkers, pieces of coal) either in roll-crushers or in hammermills. Insofar as they cannot be pulverized, they can be removed by a ballistic separator, which removes those metals that have not been already extracted magnetically. The ballistic separator as well as the roll-crusher have proved to be efficient machines, especially if they work in series one after the other. They yield better results than the roll-separators or the inclined conveyor-separators, which otherwise can be very useful in small installations.

Plastic presents the greatest difficulties. This substance cannot be pulverized and cannot (or only partly) be removed by means of ballistic separation. As a result of this, part of the plastic remains in the compost, which is a serious drawback. It spills the outward appearance and sometimes causes trouble (especially the foil) with the finer tillage work.

It should also be pointed out that, apart from the above-mentioned methods of purifying compost, extensive experiments with wind separation were made some years ago. Wind separation was even employed for some years in the plant in the province of Drenthe, but this method was again abandoned. At the moment, however, experiments are being made again in order to blow the plastic foil away from the disintegrated refuse. This may be successful, as the foil is very light.

The most usual working method, which results in keeping away many undesirable objects from the compost, is to avoid grinding or rasping the city refuse too much. This means, however, that the residue becomes considerable. Consequently, part of the organic matter is also lost. This not only is unfortunate in itself, but even worse is the fact that it must be taken to a dumping place or to an incinerator. If the disposal of refuse is the object in view, that goal is only reached in part, e.g. up to 75%. For the remaining 25% and for the unworkable industrial wastes, a dumping place or an incinerator is necessary.

If the production of organic manure is the main purpose, it does not matter that 25% gets lost, seeing that there is refuse enough in the world. Most probably it is even cheaper to use 130% with a yield of 75% than to use 100% with a yield of 95%. The final stages are the most expensive.

I wonder if we shall yet have to proceed to screening and whether we shall be able to render this possible, perhaps through natural drying to such an extent that the compost can be screened after it is ground in a rotating drum with pins which serve to break the lumps into pieces). It may be that by blowing air through the fermenting compost heaps - if necessary in combination with repeated turning - the proper conditions for screening the compost can be created. It will be necessary to use screens of a very good quality. As far as I know, systematic examinations in this field have hardly been made thus far.

In summary it may be stated that the main problem is: how can municipal refuse be processed to reduce the amount of unworkable residue, without detracting from the quality of the compost.

Fermentation Processes

Now I would like to say a few words about fermentation.

Fermentation is necessary, because bacteria would withdraw nitrogen from the soil, if disintegrated refuse were immediately applied. Moist organic matter is disintegrated by bacteria. We see this everywhere in nature. Because bacteria need nitrogen for cell production, they take it wherever they can get it. So if fresh refuse is put into the soil, the bacteria deplete the soil of the nitrogen, thereby damaging plant life which also requires this element.

The field of fermentation has been widely researched. In the first place, it was of importance to investigate whether the disease germs present in municipal refuse survive the process of fermentation. The temperatures range is 50 to 80 degrees Celsius, which is not a very high temperature for killing bacteria and their spores. Yet investigations have proved that disease germs cannot survive the long period during which this temperature is maintained. It also appears that this was due not only to temperature, but also to the antagonistic action of the other bacteria.

Thus we may consider compost to be harmless from a hygienic point of view, provided that it has been subjected to fermentation at elevated temperatures. This is particularly significant in the case of bacteria causing plant diseases, which may occur in municipal refuse, and also in the case of bacteria present in sewage sludge when it is mixed with refuse.

Therefore, sewage sludge should always be added to the refuse before the fermentation process takes place. As you know, sewage sludge in itself is not free from pathogens even when it has been fermented. To be sure that pathogens are destroyed, the temperatures during fermentation should be raised. In the case of aerobic fermentation, there is always a rise in temperature; in the case of anaerobic fermentation the temperature rises, but very little.

Much more could be said about aerobic and anaerobic fermentation. In the first place the distinction between aerobic and anaerobic fermentation has not yet been clearly defined. It is very likely that a fermentation process is often called aerobic, while the inside of the heap does not contain any oxygen whatsoever. Generally speaking, aerobic fermentation is preferred, but I am of the opinion that a fermentation process which is slightly anaerobic is not only harmless, but may even result in a better product.

When examining a heap of disintegrated refuse with a height of 1-1/2 to 2 meters from the outside to the inside, it is found that there are 4 to 5 clearly distinguishable layers, from purely aerobic to purely anaerobic.

The outer layer is brown, the inner core black. These layers are formed within a period of a few weeks. The turnover of the heap results in the mass becoming homogeneous again. The formation of these layers may be a useful starting point for studying the process of fermentation. It has already become evident that the products of these layers not only have different times of fermentation, but also has different qualities. The Compost Foundation in Amsterdam has some interesting data on this subject.

Further research is necessary. This should include the Verdier system, in which the first phase of fermentation takes place at an accelerated pace, while the mass is being turned over repeatedly. This results in a product of good appearance, but it is doubtful whether this justifies the high costs involved.

Inoculants need not be dealt with at this time; it is known that they have no value in the process of fermentation. Valuable, however, are admixtures such as ashes, earth, street refuse, ripe compost, etc., particularly if the refuse one-sidedly consists of paper. Also, it is advisable to mix street refuse with household refuse if, for example, it contains a great deal of sand. Satisfactory results may be achieved by the admixture of these materials, but it is doubtful whether they should be added to disintegrated refuse, if this involves extra treatment.

Another important point, which has not sufficiently been clarified, concerns the influence of blowing air through refuse in order to promote the process of fermentation. We have mentioned this point before in connection with controlling the percentage of moisture of the fermenting refuse. In this regard the question of aerobic or anaerobic conditions should also be considered.

A question apart - and a subject about which much has been written and is still being written - is: when may the compost be considered to be ready for use? It is generally held that the fermented refuse can be used as compost when the C:N ratio is lower than 20 to 25.

Without entering into details, however, it is certainly much too cumbersome to determine the carbon and nitrogen content of each heap of compost. Moreover, the exact limit of the C:N ratio is not certain. For agricultural use it will not be harmful if the C:N ratio is somewhat higher, but for more delicate market and garden crops such as lettuce, one should beware of bacterial fixation of nitrogen.

In actual practice, ripeness is as a rule judged on the basis of the following factors:

1. period of fermentation
2. pH
3. temperature
4. outward appearance.

Uses for Compost

Now for the third point: the use of compost. It is very important to study the use of compost as manure and as a means of improving the soil. If the compost is not put to use, all efforts to produce it are of no avail. The only remaining possibility then is to use the compost as cover material on a sanitary landfill.

Over the years not hundreds but thousands of experiments have been made: pot experiments: field experiments; practical experiments on sandy soil, on peat soil, on light and heavy loam soil; with agricultural products, with horticultural products, in vineyards (Germany) and in tree nurseries (Switzerland).

The science of fertilizing is a special branch which is better left to agricultural experts. But I would like to point out that particularly in this field, research work is necessary and desirable. Local conditions play a very important part. Soil, climate, rainfall, tilling methods, etc., have a considerable influence in the results of manuring. It is, therefore, of importance that the experts concerned should conduct research on a local level.

The following will give you an impression of the extent of our knowledge of the uses of refuse compost particularly in the Netherlands:

1. In agriculture compost yields the best results on those soils which are naturally poor and drought-sensitive. These are primarily the sandy soils and peat soils. Apart from supplying organic matter, the trace elements are very important. Not all plants react the same when compost is added to the soil. Examples of compost-loving crops are sugar beets, mangolos, potatoes and turnips. In agriculture, compost is seldom used on heavy soils, since other types of manure are generally preferred.

2. In horticulture, on the other hand, preference is given to compost especially on heavy soils, but also on sandy soil and peat soil. Good results are obtained not only with all kinds of vegetables, tomatoes and cucumbers, but also with bulbs and in orchards, vineyards and tree nurseries. For citrus cultivation (in Israel), compost made from municipal refuse also has been used with great success. In particular for the Netherlands with its many hotbeds and greenhouses, the use of heating manure is important.

3. For non-agricultural purposes, such as playgrounds, parks, gardens, etc., the use of compost is preferred. Compost increases the water absorbing capacity and improves the structure of the soil, which is particularly important in the case of athletic fields.

To the best of my knowledge, it has not yet been investigated whether food manured with compost is beneficial to human health. With regard to cattle, it is known that compost counteracts disease and promotes proper growth. But it should be remembered that nutrition for cattle is often one-sided. Because humans have a more varied diet, there is less danger that the supply of trace elements will be deficient. In my opinion, it would be important to investigate whether organic manure is general, and refuse compost in particular, have a favorable influence on the health of man.

At present, about 25% of all city refuse in the Netherlands is processed into compost. Roughly speaking, compost (more than 200,000 metric tons per annum) is applied one third in agriculture, one third in horticulture and one third in parks, gardens and athletic fields.

Summary

The most important points which should be investigated with regard to the preparation and the use of municipal compost are:

1. From a technical point of view: a high yield combined with a high degree of purity.
2. With respect to fermentation:
    a. investigation into the advantages and disadvantages of aerobic, semi-aerobic and anaerobic fermentation;

b. Judging the ripeness of the compost.

3. With respect to the use of compost as manure: To build on the knowledge and experiience already gained. It should be borne in mind that the question on which soils and for what purposes the use of compost yields good results, has to be examined for each country individually.

GENERAL DISCUSSION

QUESTION: Mr. Weststrate, has it been determined how much compost can be put on the same piece of ground over a period of years? Is there a certain amount of inert material. You start out with a soil, and build it up; but just how long can you continue to add?

MR. WESTRATE: There is a limit. The farmer uses it once every four or five years, but many have used it for about twenty years, that is, about five times. Maybe he doesn't need it any more for the first time in twenty years, mostly because of lime content. Compost has 2-1/2 percent lime, which raises the pH of the soil. Sometimes we advise against using compost every year, and recommend stable manure instead. I must say that there is little evidence of harm when compost is used repeatedly.

QUESTION: Isn't the high lime content mainly due to the ashes and cinders in the raw refuse?

MR. WESTSTRATE: Yes, when we had more ashes some years ago, we had 3 percent of lime. Now we have 2-1/2; so I suppose, it is the ashes.

COMMENT: In Europe, there is a higher ash content in the refuse, except possibly in Pennsylvania or somewhere near the coal mines where they burn a lot of coal.

CHAIRMAN MICHAELS: So then, this disadvantage of excess lime might not apply.

PROF. MOLOF: Speaking not of the processing before composting, but after you start windrowing, have you ever tried to accelerate field conditions by over turning every day or two?

MR. WESTSTRATE: Yes, we do it every day.

MR. COOKE: In the Van Mann system, you mentioned an odor problem. What about rats and flies?

MR. WESTSTRATE: We have to fight them. We spray with chemicals and insecticides. We don't have many rats, but we kill them sometimes, so that is a disadvantage. With the Van Mann system, there are no rats or flies, but the disintegration by machine is much more expensive.

PROF. GAUDY: You say the rasping process also obviates the need to worry about odors. Is this because of the classification? That is, are you taking out materials that would give odorous compounds in the fermentation process; or does this somehow enhance aerobic conditions?

MR. WESTSTRATE: There are different ways to combat odor. You can cover the fresh fermenting compost with fermented compost that is about six months old. Or you can spray with water, or odor-masking chemicals, but they are only partly effective.

PROF. GAUDY: I understood you to say that if you use the rasping or grinding process first, then you don't have to worry about odors. What is the reason for this?

CHAIRMAN MICHAELS: I think the answer is that, by rasping, you expose so much of the surface to aeration that you create an aerobic condition.

MR. WESTSTRATE: I have never heard a good explanation of why there is no odor, but we are thankful for it.

MR. SPITZER: I had a conversation two weeks ago with the people who are running the plant in Kingston, Jamaica, and they mentioned the same thing. They don't know the explanation, although they have tried to find out. They claim that rasping and grinding eliminates odors and fly breeding.

MR. WILEY: In Chandler, Arizona, with windrow composting, we sampled for oxygen at various depths in the windrow; and, while the oxygen content at the 24-inch depth dropped rapidly to one percent, it seldom reached zero. There were only two tests that gave us zero oxygen, even in the bottom of the window.

CHAIRMAN MICHAELS: What size windrows were you using?

MR. WILEY: About five feet high.

MR. WESTSTRATE: Ours are a bit higher, but we made the same observation. Inside you will not always get, but you can get completely anaerobic conditions, especially when the compost is too moist.

MR. CLARKE: When this is so, and you turn the pile over and there are anaerobic conditions inside, is there odor at the time you are turning it over?

MR. WESTSTRATE: Yes, there is a slight odor, especially when the conditions are too anaerobic. You can see it is aerobic outside, and semi-aerobic inside. But scientists do not agree on where aerobic conditions end and anaerobic conditions begin.

QUESTION: How do you control the moisture?

MR. WESTSTRATE: The windrows have layers. The first layer is aerobic; and then comes the second layer, about eight inches thick and gray white with molds. It is partly permeable to water. If the heaps are too moist, turn them and they will dry.

QUESTION: Do you sprinkle them when they are dry?

MR. WESTSTRATE: Yes.

QUESTION: Have you found any way of disposing of the plastics in the compost?

MR. WESTSTRATE: We are trying out wind separation, but it doesn't work well. Plastic foil is very light and is easier to remove, but there remains the plastic from toys, etc. Therefore it is better not to grind too long. The demand is for clean compost--no plastics, no glass.

MR. WILEY: Doesn't your screening get rid of a lot of the plastics?

MR. WESTSTRATE: Yes, I had thought it would be better to screen them out after fermentation; but then you have to have it rather dry, otherwise it doesn't go through the screens. The holes are about five-eighths of an inch, and it is difficult to screen through these fine meshes. I suspect that when we blow air through the windrows, we may succeed in this, but that is a subject for research.

MR. NEILL: You mentioned that thirty-five percent of the refuse in the Netherlands is now being composted. Is that a significant increase over the last decade? What is the future of composting in the Netherlands?

MR. WESTSTRATE: Our population is growing rather fast, and the amount of refuse per inhabitant is going up, so I suppose composting will continue to grow, but the percentage will be about the same. It will remain at about thirty-five percent. There is one compost plant under construction and two or three compost plants are planned, but when they are finished, we will need more. Agriculturally, the demand for the compost is greater than the supply.

MR. NEILL: Is it private capital that builds these plants, or is it governmental?

MR. WESTSTRATE: The refuse compost company is a semi-government plant. The stocks are in the hands of the Minister of Agriculture. We have no private plants, and private capital is not interested. You have to look upon a compost plant as a means of refuse disposal. It costs money, and you cannot earn a profit. It costs about the same yearly per ton of refuse as incineration.

MR. WILEY: Is that including the sale of the compost?

MR. WESTSTRATE: Yes. When you have an incineration plant, we make steam and sell the clinkers. In the compost plant, we sell the compost.

MR. BREMSER: What do you charge for compost delivered to the farmer?

MR. WESTSTRATE: For agriculture, we charge about 16 guilders (about $2.85) a ton. But you cannot compare that to the United States, since standards are different. The price of compost is higher than the price of stable manure. Prices have gone up considerably. In 1950, the average price was about 25 percent lower than it is today. Every year we raise the price a little.

QUESTION: In the municipal waste, is the microbe and flora content great enough to start the compost, or do you have to add something to get complete fermentation?

MR. WESTSTRATE: We don't add anything. In 24 hours, the temperature begins to rise.

PROF. MOLOF: Have you ever tried adding semi-finished compost to raw composts?

MR. WESTSTRATE: Yes, we did that, and it is helpful. Street refuse, earth, or even sand, is helpful, but not economical.

MR. SPITZER: As long as you are doing about 25 percent composting, and the rest, I presume, is incineration, what would normally be the deciding factor as to what plant you are going to build next? What are some of the deciding factors as to whether you will have incineration or composting?

MR. WESTSTRATE: That is a difficult question. Let me first say that 25 percent of the refuse is composted, 25 is incinerated, and 50 percent is dumped. The larger cities in Holland, from 500,000 inhabitants upward, tend to incinerate. The general opinion is, for such quantities, incineration is cheaper. I don't know if this is true. We have had no incineration plants built after the war, and when you consider the cost of incineration, it depends upon the cost amortization. A plant for a city of 700,000 inhabitants costs 30 million guilders (about $8 million). Writing it off in 30 years, 40 years, or 25 years, makes a difference. So we don't quite agree about the cost. But there is a general feeling that for smaller cities, from 50,000 to 100,000, composting is cheaper, especially if they are situated in a part of the country where there is need for compost.

CHAIRMAN MICHAELS: Do you have any idea of the amount of garbage or food waste that is in the refuse which is composted?

MR. WESTSTRATE: It is less than in your country, since some food wastes are collected by the farmers for stock feed. This is ending now, because we have a shortage of labor, and prices of stock feed are going up. In refuse it is about 15 percent.

CHAIRMAN MICHAELS: This is by weight or by volume?

MR. WESTSTRATE: By weight, but we have much paper and packing material.

CHAIRMAN MICHAELS: In other words, the bulk of the composted refuse is paper and paper products.

MR. WESTSTRATE: Yes.

CHAIRMAN MICHAELS: Let me ask you another question. Are some soils suitable for the addition of compost, and others not suitable?

MR. WESTSTRATE: Yes. As a rule, you can say poor soils need compost most: but where they want to have soil that has a very good structure, the heavy soils need it just as well, perhaps even more; and then, sometimes we apply compost mixed with peat--50 percent compost, 50 percent peat. That works very well.

CHAIRMAN MICHAELS: Has anyone in the U.S. made a study of the soil to determine its affinity to compost?

MR. WILEY: One of the biggest needs in this country, is to determine value of composts to the land. Many of the tests in the past have been made for one of two reasons, to find out if there is anything deleterious or harmful in the compost; and they have, so far, not shown anything of that nature. Another need is to understand the differences between composts and fertilizer. Compost is not a fertilizer but a soil builder, and it has other values--moisture holding capacity, prevention erosion, improving the fill, improving the structure, the tillability. These things have not been investigated in this country, and that is the urgent need for research in the field of compost. We have no market at all in this country to the farmer.

MR. E. WRIGHT, JR.: But we already have green manure. That is, the farmers are plowing plant material back in. This is much better than using compost. Also, nitrogen sells for about $50 a ton, whereas in Europe it is much more. The farmer can get much better results with nitrogen and green manure than with compost.

MR. WILEY: Is it still true that the Netherlands not only uses more compost than any other country, but also more chemical fertilizer per acre than any other country?

MR. WESTSTRATE: We have the highest chemical application rate in the world. I am not proud of that, but it is a fact. I agree that when you have good soil, you can add green manure, and it is probably cheaper. For instance, in the newly reclaimed area in the Netherlands, they don't use compost, because green manure is better.

MR. E. WRIGHT: Another thing is the mechanization of the American farm and the size of the farms here. Because mechanization is economical, the use of the mineral fertilizer is also advantageous.

MR. WESTSTRATE: Yes, but compost is easier to spread mechanically than stable manure. For instance, some of the growers use compost even though stable manure would give better results because they can spread compost mechanically.

DR. HEUKELEKIAN: It is not a question of either compost or commercial fertilizer. Each has its place, and each does something the other doesn't do. The fact that in Holland they use both compost and commercial fertilizers, is an indication of this.

CHAIRMAN MICHAELS: Do the farmers who use compost also use commercial fertilizer?

MR. WESTSTRATE: Only on the poorer soils. On better soils, they don't. They use only chemicals. On the poorer soils, they don't come out with chemicals alone; they need composts or stable manure. Chemicals are almost always used with compost.

QUESTION: Has any pharmaceutical house determined why pigs are more healthy when they eat compost? What is in the compost that makes the pigs healthier?

MR. WESTSTRATE: Compost helps them, but we don't know exactly why.

COMMENT: Maybe this is an area for research.

MR. WESTSTRATE: Yes, it is.

COMMENT: I understand then that you are using compost not only to increase the soil pliability, but also to supply trace elements.

MR. WESTSTRATE: Yes, mainly to increase pliability but also to provide trace elements in the poorer soils.

DR. HEUKELEKIAN: It is very probable that the beneficial effect on young pigs eating the compost is due to vitamine B_{12}, because as Mr. Weststrate said, the compost has billions of microorganisms per gram, and this is the only source of vitamin B_{12} we have. It may have also a residual effect on the plant.

CHAIRMAN MICHAELS: How big is the largest compost plant within the city limits of a city in the Netherlands?

MR. WESTSTRATE: The city of Arnhem (150,000 inhabitants) has an 8-acre plant with three machines, including storage and curing facilities.

MR. COOKE: I wonder, are there any peak periods for dispensing compost? When is the greatest demand from the farmers?

MR. WESTSTRATE: Compost is used mostly in the fall or in the spring, sometimes in winter.

MR. COOKE: Does this create storage problem?

MR. WESTSTRATE: No. The Van Mann system does not operate during the summer, that is from May until August. Actually, the refuse is brought in every day, and the fermentation goes on every day, only we do not make any deliveries.

CHAIRMAN MICHAELS: What happens to the noncompostables.

MR. WESTSTRATE: That is not the best side of composting. You can use incinerators or dumps. We reclaim it.

MR. DOMINICK: Mr. Weststrate, you mentioned that flies are controlled with insecticides. But is it possible to achieve complete control?

MR. WESTSTRATE: We kill the flies only in the Van Mann system. Two plants are in isolated places. But plants which are within the city limits are either rasping plants or Daman plants, and there are no flies. That is the difference between fermenting food refuse and fermenting disintegrated refuse.

DR. HUEKELEKIAN: The incorporation of noncompostables into the compost reduces the value of the product, does it not?

MR. WESTSTRATE: Yes, considerably. You cannot sell it; no one will have it.

PROF. SMITH: Do any pathogens remain after fermentation takes place? I imagine that the 80° Centigrade temperature would kill the harmful organisms.

MR. WILEY: In windrow composting the outer layer and the bottom is cooler. It is not even up to 45° Centigrade. So, in windrow composting, are we absolutely positive that pathogens in the outer layers eventually get turned inside and get exposed to the high temperatures?

MR. WESTSTRATE: I think we can be fairly sure of that, because we turn the compost over two times, sometimes three. But then, it is not only the temperature which kills the disease germs, but also the synergistic action that takes place. We have never had any complaints about that during my thirty years.

MR. E. WRIGHT: There are many problems that need research: (1) What is the best method for composting? (2) Do additives help? (3) How do you develop the market for compost in competition with sewage sludge which is cheaper to apply. (4) How do you go about developing a market in each location. How far can you distribute it? There are quite a few problems here in the United States as far as composting is concerned. TVA is interested in organics at the present time, and we expect to find out more in a few years.

COMMENT: Add one more research problem. That is, the integrated sewage sludge composting process. It is costing us money now to get rid of sewage sludge.

MR. WESTSTRATE: We have also tried placing a 2-inch layer of raw ground refuse directly on the soil. It is immediately plowed under, and ferments during the winter. The results have been good.

CHAIRMAN MICHAELS: But what about the pathogens and other harmful organisms? Could this be done for root crops?

MR. WESTSTRATE: Yes. We are not afraid of this.

QUESTION: What do you do with the tin cans?

MR. WESTSTRATE: We can sell them, but the price is very low. In the newer plants, we don't extract them. In the older plants, where we have magnets, we can extract them, and it pays. The percentage of glass in the refuse can be from one to two percent.

CHAIRMAN MICHAELS: That compares with perhaps five to ten percent in our refuse.

MR. E. WRIGHT: Glass splinters make the compost useless. If it is ground up into a sandy material, then it is perfectly all right; but that extra grinding is an expensive operation.

CHAIRMAN MICHAELS: Thank you very much, Mr. Weststrate. We appreciate your presentation.

Concurrent Panel Session

Procession, Conversion and Utilization of Solid Wastes

Group D

Procession, Converting, and Utilizing Solid Wastes

P. H. McGauhey
Director, Sanitary Engineering Research Laboratory
University of California
Berkeley

General Considerations

Although this paper deals with but three specific aspects of the problem of solid wastes, isolated for scrutiny by one of several study groups, the three are so interrelated with other aspects of concern to this Conference that it seems necessary to give some consideration to the framework within which they must be evaluated. If the Conference is to achieve its purpose of generating new ideas for research, some spotlighting of the past is unavoidable. Particularly is it important to summarize what has been learned from past studies and to evaluate the technical, social, and economic reasons why progress toward a solution to problems of solid wastes management continues to lag. For there is no gainsaying that adoption of results of research completed in the past 15 years has been disappointingly slow.

In establishing a rationale within which to discuss the three specific aspects of solid wastes management and, indeed, in the discussion itself, I must draw heavily upon the experiences of the Sanitary Engineering Research Laboratory (SERL) of the University of California, with which I became associated soon after its inception in 1950. Many of you may have forgotten that SERL began as a project financed by the State Legislature for the express purpose of searching out improved methods of municipal refuse disposal. Although following initial studies (1, 2, 3, 4)* of composting, incineration, sanitary landfill, and refuse handling reported during the early 1950's, the Laboratory extended its interest to include other urgent environmental problems, interest in solid wastes problems has continued through the years. The SERL group has participated in studies of fly control and composting of animal manures conducted by the California State Dept. of Public Health; disposal of cannery wastes (5), conducted by the National Canners Association; and management of rural wastes, conducted by the University on its Davis campus. The principals in these studies, Messrs. Ralph J. Black, Walter A. Mercer, and Sam A. Hart are, of course, to be featured in this Conference. In recent years the SERL staff has also assisted in the preparation of APWA and ASCE manuals on refuse disposal and sanitary landfill, freely consulted with those desiring to make new methods commercially feasible, and has conducted an analytical study of refuse collection for the U. S. Navy (6). I call attention to these activities of my own organization merely to advise you of its continuing interest in solid wastes problems and to justify my personal participation in the Conference. Obviously, if any of us present had cause to boast of our accomplishments the Conference would not have been necessary.

Scope of the Solid Wastes Problem

Essentially all environmental problems first reach a critical mass in cities, consequently the city is the sector of the community which tends to establish the pattern other sectors later attempt to follow when confronted with similar problems. When dealing with new environmental problems the city itself tends to follow its own established habit patterns.

Traditionally the solution to environmental problems has involved going "beyond" the confines of the populated community. First it was to develop potable water supplies -- a solution which more than any other factor accounts for the continuance of cities into modern times, following the water-borne catastrophies of the Middle Ages. Later, this same concept of seeking a solution by exporting the problem came to dominate waste disposal as well, liquid and solid wastes being discarded in the cheapest possible manner beyond the confines of the city. In the case of human and industrial wastes which might readily be water transported, both cheapness and convenience led to the early adoption of sewers designed to conduct such materials to some natural receiving water beyond the range of sight and smell of at least the most influential urban citizens. As for the solid wastes, a portion was likewise hauled a minimum distance beyond the city limits and dumped on the countryside. The remainder was even more cheaply managed by burning it essentially at its point of origin, thus converting it to particulate matter and gases which, hopefully, might be diluted by the air mass over the city and ultimately transported elsewhere -- beyond -- at no cost, by the wind.

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* Numbers in parentheses ( ) refer to the appended references.

Freedom to manage wastes by simple export from the city is now vastly constrained. For some time it has been virtually impossible to export water-borne wastes beyond the city limits unless they are first upgraded in quality. The crisis in solid wastes management which generates this Conference derives from the fact that the same is becoming true of solid wastes. Already it is difficult to export rubbish, garbage, cannery wastes, and debris from urban redevelopment and freeway construction. Burning it at any economically feasible location faces restraint by air pollution control authorities, and landfill presupposes the availability of cheap unoccupied lands. Thus the problem of disposing of large volumes of both solid and liquid wastes within the confines of the city is added to such other traditionally unexportable problems as vector control, housing, mental health, and environmental sanitation to which they bear an increasingly distinguishable relationship. What has happened to restrain the freedom of cities to export solid wastes? The answer lies in an understanding of the modern community and of the competing jurisdictions which seek unilateral solutions to waste problems by emulating the patterns established long ago by the city.

The rapid spread-out of cities, popularly known as "urban sprawl," which followed World War II is widely recognized as having revolutionized our concepts of urban life. Not so well understood, however, is the impact of this phenomenon on the problems of waste management by the myriad jurisdictions which seek to cope with them. Particularly in areas where explosive population growth has been most pronounced, of which California is a notable example, urbanization has progressed beyond the city limits, even beyond its satellite suburbs, to become a characteristic of rural areas as well. These rural areas are themselves characterized by high land values and heavy investment in fixed installations dedicated to specialty enterprises. Thus in many instances the urban-industrial sector of a community is surrounded by a rural shell that has lost the elasticity historically associated with country areas. Moreover, this rural sector exists in sufficient depth to have a profound effect on both its own and the city's problem of solid wastes management.

Just as the city is restrained by its surrounding rural sector, so does it exert a restraint on the air-polluting, water-polluting, vector producing, and other adverse environmental potential of the sector. Nuisance abatement laws are directed against the fly and odor nuisances arising from animal feeding pens, dairy barns, egg and poultry production plants, etc.; or city limits are extended to overwhelm rural enterprise with ruinous taxes. The farmer is faced with the choice of going out of business, to the disadvantage of the entire community, or finding some way to deal with wastes himself in order to resolve the environmental problems his activities create. In seeking a solution the farmer too finds that export of his problems is infeasible. There is no place "beyond" to which he can deliver wastes economically, or to which he can deliver wastes economically, or to which he can move his enterprise. Piling manures on the ground leads to odor and fly nuisances; burning tree trimmings and other agricultural wastes aggravates the air pollution problems already begging solution in more than 10,000 U. S. communities as a result of urban-industrial activities; burying wastes in the soil may increase crop diseases and insects, thus requiring more intensive use of stronger pesticides. These, in turn, increase the exposure of man to toxic materials in his food and water supply.

It has become evident in recent years that solid wastes management has taken on a community-wide dimension involving all sectors -- urban, suburban, and rural -- of the modern community, and this community has generated problems of solid wastes management faster than research and development has provided answers.

Fragmented Jurisdiction

The normal fragmentation of governmental jurisdiction whether at the administrative, regulatory, operative, or investigative level, precludes an effective direct attack on a problem such as wastes management which involves simultaneously the urban, industrial, and rural sectors of the community and which has overtones in a variety of environmental control agencies other than those whose primary interest is in solid wastes. The effect of almost any suggested discrete solution to a problem in solid wastes, therefore, is merely to change the name of the agency responsible for enforcing restraints. Jurisdictions for environmental control exist at all levels of government. They include public health departments; water pollution control boards; air pollution control districts and boards; sanitation districts; fish and game commissions; park and recreation departments; agricultural agencies; and so on. Under their uncoordinated aegis significant and highly important research projects have been directed to specific problems pertinent to solid wastes management. The results have been, and continue to be, productive and revealing, but the fact that a Conference on Solid Wastes Research is needed is evidence that they fall short of suitable resolutions to the solid wastes problem. They also underscore the fact that the problem is too complex to attack or to resolve in toto within the framework of any single local fragment of the governmental structure of the community. The same may be said for a single agency such as, for example, a health department, which finds it necessary to divide itself into sections designed to attack discrete facets of the overall problem. Often the result is that a solution which satisfies the criteria of one section increases the problem which confronts another; e.g., a problem in vector control becomes a problem in air pollution in accord with some law analogous to that of the "conservation of energy."

Today both the limitations of functionally oriented agencies operating within narrow jurisdictions, and impacted sectors of the community are involved in the failures to which this Conference is addressed. Such agencies and jurisdictions might be said to be vertically compartmentalized, whereas the greatest dimension of the problem confronting them is horizontal, extending across the urban, suburban, and rural sectors of the community and involving solid wastes of municipalities, industry, commerce, and farmers. This problem is compounded by the fact that too few levels of society are concerned with the solid wastes problem, the tendency being to consider it a matter for resolution at the technical level, subject to constraints imposed at the levels of planning, administration, politics, economics, and sociology more to keep it from fouling up these areas than to contribute to a rational solution. This more than any other single facet of the problem of wastes management accounts for the failure of technological research to solve the problem of solid wastes management and leads me at the very outset to the assumption that research may now have to be directed beyond technical and economic considerations into areas of public policy, planning, and the social goals of our society.

Public Attitudes

The attitudes of citizens, engineers, public officials, private entrepreneurs, and other elements comprising the "public" contribute in an important manner to the creation of solid wastes problems and in inhibiting the development of logical systems for their solution. One needs only to consider the phenomenon of the "litterbug" to observe that there exists a "swinish" thread in the character of even the most civilized of our citizens. Perhaps it is an outgrowth of the long American tradition of waste -- i.e., of discarding or destroying any unwanted item in the cheapest possible manner. It might be said that any material becomes a "waste" whenever its owner or producer no longer considers it of sufficient value to retain. Any suggestion that he should thereupon invest more money in it, for the sale of disposal or any other financially unrewarding goal, is likely to be considered absurd, however inclined the citizen may be to object to polluted water, smog, rodents, odors, unsightly debris, and other conditions which result from his loss of interest in ownership.

Ensnared in the public economic spirit of citizens, engineers and officials responsible for wastes management have tended to apologize for the fact that their systems cost anything whatsoever, often retreating from expedient to expedient on the basis of cost in dollars instead of leading the public to an understanding that solid wastes management is worth whatever it costs within the framework of honest engineering and sound public health practice; and that this cost is part of the price man must pay for the benefits of a modern urban-industrial-agricultural society.

Similarly, the administrative officials of a community often mistake a policy of "no-spending-at-all" for the ideal goal of government, or find it more politically and socially rewarding to confine tax spending to more popular public works, or to monumental developments having greater cultural appeal than wastes management. On the other hand, the official may encounter irresistible public pressure if he deviates from traditional methods of refuse disposal in a manner which results in a profit to a private corporation even though it leads to reduced costs to the public.

The attitude of the private commercial entrepreneur contributes in its own way to the problem of solid wastes management. As explained in a later section of this paper, ownership or long-term rights to raw materials is fundamental to any investment in private enterprise where the value added by manufacturer is not outstandingly great. Thus the inability of solid wastes to yield a high return on investment leads to a commercial disinterest in most problems posed by such wastes.

However, if the citizen is to be inspired to follow the lead of his technical and, political representatives and to accept the cost of proper wastes management as his civic duty we must first be prepared with an effective system and an estimate of its cost. To this end we turn our attention to the needed research.

Specific Aspects: Processing, Converting, and Utilizing

It is difficult to isolate any single aspect from the many interrelated facets of solid wastes management. However, for the purpose of this discussion an attempt is made to consider Processing, Converting, and Utilizing as separate individual subjects -- related to other aspects of the solid wastes problem through the concepts outlined in the preceding section.

Processing

In order to limit encroachment upon the subjects of other speakers, "Processing" is here considered as that which is done to convert a waste into something useful, leaving the term "handling" to describe what is done to prepare it for disposal. Thus processing may include segregation of a mixed waste in order to isolate some particular fractions for further processing, as well as the procedures and methods applied in converting such fractions to useful products. To speak of processing solid wastes is meaningful only with reference to specific waste materials. Technical research may likewise be expected to be fruitful only when applied to particular aspects of the overall solid wastes problem.

Some of the earliest instances of wastes processing have generally disappeared for reasons other than a lack of economical techniques. A prime example is the cooking of garbage for swine feeding. Research produced some quite efficient cooking and handling equipment, and there was no decline in the market for pork. What happened was that increasing standards of environmental sanitation and aesthetics reflected in zoning ordinances confronted the hog raiser with the old question of going somewhere "beyond" -- a solution which was either impossible for lack of suitable sites, or impractical because of excessive distance between the city and the hog farm.

A similar fate befell the rendering of garbage for reclamation of grease and the production of tankage, albeit for a quite different reason. In this case the development of substitute materials and general opulence of the economy caused the near demise of this never popular expedient.

Fermentation as a method of disposal of solid cannery wastes scarcely got past the idea stage. Although technically feasible and often suggested as a subject suitable for research, great volume of waste occurring over a short period, plus the existence of cheaper ways to produce industrial alcohol, removed fermentation from the list of imaginative and economical possibilities to which research might be directed.

Concerning the more recent approaches to solid wastes problems, adequacy of current processing methods suited to such approaches range from reasonably satisfactory to essentially non-existent. In the former category might be separation of refuse for salvage purposes or for a combination of salvage and preparation for composting or incineration. Here a combination of methods involving hand picking; vacuum, magnetic, and ballistic separation; and screening have proved effective although not necessarily as economical as might be desired. One of the needs for research recently pointed out by the APWA (7) is new procedures for salvaging waste materials.

Shredding of municipal refuse for composting is a process which is not yet totally satisfactory. This is not to say that composting as a method of wastes conversion is delayed for lack of acceptable shredding equipment. Rather, lack of adoption of the process delays the ultimate development of shredding machinery particularly well-suited to U. S. refuse. In the interim equipment has progressed beyond the stage when an overlooked metal bolt will wreck the shredder, but the problem of resistance to abrasion still exists. Thus although there is room for specialized research on shredding equipment and methods it is not the research needed to overcome current problems of municipal refuse management. The same may be said of equipment for shredding tree trimmings for disposal to the soil of an orchard. While the nature of the most economical shredder remains undetermined, the most overwhelming problems concern the technical difficulty of collecting the waste, and the problems of nitrogen robbing, and of insect and plant disease reservoirs which shredding to soil may create. Although the existence of a problem or a problem area is normally a signal for research, the task of writing a research proposal around the processing of orchard wastes to produce a beneficial solution to the disposal of this faction of the community's solid wastes has generated little enthusiasm among research groups. The challenge seems to be confined to that of developing an economical process for doing something no one particularly wants to do.

One problem which has thus far defied solution arises with the solid wastes produced in urban renewal projects and freeway right-of-way clearance. Thus far no one has suggested a way in which research can be brought to bear on the problem of processing the remains of old houses and tree trunks whether for disposal or conversion to something useful. Profitable contracting work requires that unwanted buildings be removed rapidly. Dismantling by union laborer is too costly to be feasible. The alternative, dismantling for salvage, leads to an overlong delay while week-end workers erode away the undesired structures. From the viewpoint of one who would process wastes to produce a useful, if low-value, product the problem seems incapable of satisfactory resolution as well as impregnable to research. Accomplishment to date seems to be confined to a sensing of need for a solution to the problem and the conviction that where a problem exists "research" is indicated.

Processing of cannery wastes by methods other than fermentation is currently the subject of research. Some of this, described by Mr. Walter A. Mercer in another session of this Conference, has proved feasible. Particularly is this true of a composting process in which finished compost is recycled for moisture control. Research in this area is continuing with good prospects for development of a successful process.

Converting

Since the goal of Processing as defined herein is the converting of solid wastes into products which in themselves have value by reason of utility, there is little that can be said concerning research directed specifically to conversion of solid wastes. This does not mean that the subject merits little consideration, but rather that a discussion of it is herein covered under the subjects of Processing and Utilizing.

Most of the solid waste material which causes a problem being organic in nature, the goal of conversion must necessarily be the production of an inoffensive organic residue. Likewise, organic residues logically find utility as soil conditioners and nutrients for growing plants. To accomplish such conversion only two processes have received much public and research interest. These are composting, and wet digestion plus ponding.

Beginning about 1950 the ancient art of composting came in for careful scientific scrutiny in the USA and Western Europe. At that time much of the witchcraft which surrounded the subject was dispelled and the fundamentals of aerobic composting illuminated. Attention was first directed to mixed municipal refuse. Later animal manures, rural wastes, industrial wastes (8), and sewage sludge became the objects of research on composting of solid wastes. Technical research on wastes conversion by composting has long since progressed beyond the stage of delineation of fundamentals. Some experimental work in practical process development is yet needed but as in the case of shredding there is little need for research into the composting process until utilization of the product, possibly as a result of research in that field, gives rise to the opportunity for process development.

Wet digestion is a hopeful process advocated by Dr. William J. Oswald of the University of California on the basis of experience with anaerobic sewage lagoons. In this process a wide variety of mixed solid organic wastes are placed in an open digestion pond to decompose anaerobically. Much of the carbonaceous matter is converted into carbon dioxide and methane. The soluble and suspended fraction going out with the supernatant is then converted to algal cells in an oxidation pond. Harvested algal cell material then has, by reason of its greater energy level, a far greater value than other converted solid wastes products.

Research to establish the engineering parameters and economics of wet digestion would seem worthy of support in the interests of resolving some problems of solid wastes management. Its virtue might well lie in an approach directed to area-wide wastes rather than to some single type of material.

Utilizing

As in the case of Processing and Converting of wastes, the problems associated with utilizing the product have been considered largely in relation to each waste as a separate entity. An important amount of research has been conducted within this framework and the possibilities of achieving more are worthy of consideration. To this end a review of the factors involved in the utilization of several wastes may reveal hopeful avenues of research in processing and converting as well as in utilizing wastes.

Salvage. Perhaps the oldest and most highly developed practice of waste utilization is the salvage of metals, paper, rags, glass, and directly re-usable objects from municipal refuse. Such an operation involves a great many problems, few of which are amenable to solution by research in its narrowest definition. From the viewpoint of the municipality, a careful study of the economics of salvage in its particular locality might be useful in judging what constitutes a proper charge to contractors for the privilege of separating and selling marketable materials collected by the city. On the other hand payment for salvage rights may not be among the factors which determine whether a salvage contractor makes a fortune, a modest living, or loses his labor and investment. Business judgment, shrewdness, expert knowledge of markets, willingness to work long hours, and access to non-union labor among family or associates may be the factors which enable one operator to make a profit in a situation where another might be unable to survive. To the salvage contractor, variability of market, lack of ownership of supply, storage space, aesthetic standards imposed by the city, investment in equipment, length of contract period, and cost of salvage rights are the principal problems. Research, within the meaning of the word as used in this Conference, can do but little to answer such problems individually, although the possibility of evaluating their total effect by computer techniques might be a fruitful avenue of research leading to a realistic assessment of the value of salvage rights in any given circumstance.

From the standpoint of the municipality a careful study of the operating space, storage space, aesthetic problems, and salvage methods required in connection with any proposed method of refuse processing would provide important information needed in considering the cost and appropriateness of alternate methods.

Composting. Composting of municipal refuse to convert organic solid wastes into a humus valuable as a soil conditioner and nutrient for plants is the alternative to conventional landfill or incineration given most serious consideration during the past ten years in communities where fill areas are scarce and air pollution control is a recognized factor. Although, as previously noted, research on ways to carry out a known process within the confines of an economical conversion plant still may be productive, the problem of utilizing compost remains a major roadblock to its adoption. A second deterrent derives from the American tradition of waste, which generates a vast public disinterest in the reclamation of organic matter.

But assuming that the absence of acceptable alternatives leads to serious consideration of reclamation, the first problem area concerns who is to produce the compost. Early proponents of composting included an extraordinary number of true believers who sought to profit through process royalties, or by the sale of inoculums alleged to be necessary to the process. This profit was to be paid by the municipality in connection with a plant owned and operated by it. Three major obstacles to any such arrangement became immediately evident:

1. Public officials will seldom invest public funds in untried innovations. There must be successful plants in operation from which to draw economic and technical conclusions.

2. Cities are not organized to engage in commercial enterprise; to produce a product, to generate a market, or to overcome public criticism when mountains of compost build up during the off season.

3. No assurance can be given that markets which might be generated for compost at the outset can absorb the volume which would result from wide adoption of composting in municipal wastes management.

Confronted with such prospects the city naturally concluded that private enterprise had best supply the investment, relying on the value of salvage plus subsidy by the city and returns from sale of compost to make an appropriate return on its investment. The factors which inhibited municipal investment in composting plants applied also to private investment. Others included:

1. Investment in composting enterprise is risky, because

    a. Necessary plant not thoroughly developed.

    b. Economics of process uncertain.

    c. Market possibilities uncertain.

    d. Value added by manufacture small.

2. Business cannot own or control its source of raw material. Refuse belongs to the public and the public may withdraw its subsidy should the risky venture begin to show a profit.

A second problem area concerns who is to utilize compost. Obviously the answer must be some segment of agriculture since compost is a soil conditioner, albeit with some value as a fertilizer. If sold in small bagged lots to the nursery industry or to the home owner, compost must compete with animal manures which are in plentiful supply and likewise present another solid wastes disposal problem. Thus marketing at a comparatively high price is feasible only to a very restricted demand. Large amounts of compost must obviously find a market in commercial agriculture. Here a series of considerations beyond simple economics arise:

1. Commercial farmers are conditioned and accustomed to the use of inorganic fertilizers, hence disinterested in compost.

2. Inorganic fertilizers are easy to apply. In semi-arid areas the convenience of application from aircraft or in irrigation water far outweighs the fact that the soil is especially in need of humus.

3. The need for inorganic fertilizers is not obviated by the use of compost.

4. Applying compost to farm land entails technical difficulties:

    a. Wet soil conditions, characteristic of the seasons when compost might be applied, lead to compaction by heavy equipment.

    b. Vibration of dry soils by equipment may produce a zone limiting to water penetration.

    c. Development of suitable and economical equipment for applying compost awaits development of demand, which in turn awaits a change in attitude toward use of reclaimed organic matter.

Research to overcome problems such as implied in the foregoing paragraphs has not been totally lacking. The Public Health Service demonstrated at Phoenix, Arizona the feasibility of composting to reduce volume of material to be incorporated in a landfill which might serve as storehouse of organic matter for use at some later date. Other experiments in the same study showed the feasibility of shredding refuse for incorporation in a landfill from which, after a few years, anaerobically composted material might be mined for agricultural use, making the land area once again available for further refuse disposal. This, as well as earlier research into the composting process itself, has given encouragement to private enterprise, which in turn proceeded with the development of various commercial composting plants. In the aggregate the results have been inadequate to launch composting on an important scale in the practice of municipal refuse management. For the purposes of this Conference we must inquire: What further research is needed either to promote the production and utilization of compost, or to put the whole subject at rest for our generation?

Unfortunately, it is difficult to find research avenues by which to approach the problems of utilization of compost on which adoption of the process depends. The need is to create a desire for organic humus on the part of agriculturists, establish an economical installation to produce compost, make suitable contractual relationships between public and private groups, develop an economical and practical method of applying compost to land.

Public relation programs based on research findings of the value of compost in the soil-water-plant cycle and the idea of conservation of resources is possibly the answer to the first of these needs. However, the low value of the product discourages investment in promotion and advertising. The other three aspects involve problems in development not readily approached by general research methods. Field scale demonstrations rather than basic research seem to be the primary need.

Animal Manures. Research on animal manures has been largely directed to processing for the purpose of removing its nuisance and fly breeding potential, rather than to its utilization. Farmers, traditionally the users of animal manures produced on the farm, are no longer interested in its utilization. As in the case of compost, orientation to easily applied, effective commercial fertilizers is the principal cause. Nevertheless if animal manures are to be utilized it must be in commercial agriculture. Dr. Sam A. Hart, who is participating in this Conference, has shown (9) that the home owner and small specialty-user market is already saturated.

Beyond the factor of disinterest, the principal problems of animal manure utilization are economic and include the cost of treatment to sterilize weed seeds, or of composting to render it innocuous. However, if utilized in agriculture the same problems of applying it to the land that confronts compost appear as deterrents.

From the standpoint of utilization alone, animal manures represent perhaps the least fruitful area for research in the solid wastes field, although processing with other wastes and on-site disposal methods are excellent avenues for research.

Sewage Sludge. The problem of solid wastes management by utilization has been better resolved in the case of sewage sludge than in that of any other solid waste which presents a problem. It has been used in a wet condition to fertilize park and roadside plantings, or, after either drying or composting, sold in the small specialty market, i.e., nurseries, home owners, gardeners, etc. Nevertheless there are several problems in the utilization of sewage sludge. As with animal manures and compost there is no agricultural demand for it. However, both small volume and production at a point remote from agricultural areas suggest that its future utilization will be confined to the specialty market. Economic factors favor the same conclusion for the cost of processing is high.

1. If sold to the home owner, sludge must be heat sterilized to protect the health of people who come in contact with it.

2. It is difficult to process, being extremely abrasive to pelletizing equipment.

When heat dried, sewage sludge is essentially unwettable, thus limiting its usefulness when applied to lawns or gardens. Private enterprise has had difficulty marketing sludge at a profit where big volumes, and hence an important problem of solid wastes disposal, exist. This experience has added to the normal disinterest of public agencies in the processing, storage, and marketing of low-value wastes. As a result, sewage sludge is often added to the other solid wastes which the city would like to export at a nominal cost and which constitute a problem that "research" is somehow to solve.

Prospects for Research

As noted in the preceding section of this paper, processing, converting, and utilizing are not by themselves the most fruitful areas to which research of the technical project type can be directed. Research in these areas of solid wastes management has customarily been applied to various wastes separately, e.g., municipal refuse, animal manures, cannery wastes. Within this framework great strides have been made through research in the past two decades. Nevertheless, utilization of solid wastes has not become a major factor in solid wastes management practice, and consequently no new refuse disposal methods have emerged even though such factors as population concentration and air pollution have placed increasing strain on conventional disposal methods.

In the absence of utilization as a strong motive in wastes management, research on processing and converting of wastes has proceeded in a partial vacuum. It has reached the point where we are tooled up to do something that nobody wants done. Further research aimed at refining the tools to their most economical and efficient state can not at present be financed or justified. Research on problems particularly directed to the utilization of individual wastes, particularly municipal refuse, seems to have subsided to a state of lethargy from which the best efforts of APWA, PHS, and other interested groups has been unable to arouse it during the past five years. Not that it should be aroused for the mere sake of more research. But the problems of waste management grow each year more urgent. What then is the answer?

To the author it seems evident that the concept of solid wastes management by each of the several jurisdictions that have responsibility within the overall urban-industrial-suburban-rural community is obsolete and such obsolescence is being reflected as impasse in research and development. However, as the problem of solid wastes assumes community-wide proportions, the prospect of processing wastes on an area-wide or total-community basis opens up new avenues for research directed to utilization as an effective measure in wastes management. Such a concept likewise gives new meaning to the type of research projects to which we have been accustomed. For example, further research along the following lines suggested by APWA (7) in 1962 take on a new urgency:

1. Development of new processes for salvage.
2. Determining new uses for fractions of existing wastes.
3. Development of on-site processing of various waste materials, e.g., packaging, composting, etc.
4. Potential market value of compost with particular reference to its merits in the soil-water-crop cycle, in comparison with other nutrient and conditioning materials.

If a community-wide approach to solid wastes management is made and utilizing converted wastes is to play an important role in wastes management, the major problems yet to be overcome lie in the areas of public attitudes, equipment and processing plant development, and economics of systems. It has already been suggested that work might be directed to the application of modern computer techniques to an evaluation of the proper charge to be made for the right to salvage in any particular situation; that studies of the technical feasibility and engineering parameters in solid wastes conversion by wet digestion and algal ponds envisioned as worthy of research; and that the whole matter of management of solid wastes from the construction industry is unresolved, although in this case processing to produce useful products does not seem the most likely direction of research To this list must be added restudies of processes for conversion of wastes in the light of a new range and variety of raw materials to be processed, as well as of the many other facets of wastes management to which other groups in this Conference have directed particular attention.

The studies which appear most urgent at the present time are those which deal with people and public institutions. Wastes management problems should be studied on a community-wide basis with regard to their overall environmental effect on man's physical and mental health; and ways sought to bring the co-ordinated efforts of engineers, health officials, planners, public administrators, legislators, etc. to bear upon the resolution of wastes problems.

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Problems of the Salvage Industry as they Relate To Solid Waste Disposal

William S. Story
Executive Vice President
Institute of Scrap Iron & Steel
Washington, D. C.

Those of you gathered here for this discussion today are fully acquainted with the general methods of solid waste disposal as used throughout the nation at present, and of the problems arising in this area. But I wonder if you are aware of the important role which the secondary materials industry plays in this entire field. The average person in the nation today dismisses with a shrug and a laugh the subject of the junk peddler, the junk shop, the scrap processor, the dump scavengers, and autowreckers. They place as much importance on the industry as they do on the objects they discard. They are vaguely aware that scrap iron, scrap metal, paper, and rags, somehow find their way back into commerce again, but they have little comprehension of how this happens. And they have no real understanding of just what would happen if this industry suddenly stopped operating. Let me say here that if the secondary materials industry were to close its doors tomorrow throughout the nation, cities and municipalities would be faced with a problem of solid waste disposal the like of which they never dreamed could exist. The difficulties encountered today in this area would be doubly and trebly multiplied, and the highways and byways of the nation would be choked with old automobiles, old refrigerators, cardboard, paper, rags, stoves, and everything else of a solid or semi-solid salvageable nature. The dumps and fills would be bursting and collections would be unable to keep pace with the accumulation. Costs of handling materials would rise steeply, and taxes in like proportion.

Please believe me when I say this is no exaggeration. For we are talking here of an industry which has gross sales exceeding three billion dollars per year in products which are never purposely produced, but which occur as the natural outcome of consumption and production, obsolescence, catastrophe, and wear. We are talking about an industry which supports not one, but three major national associations--my own, the Institute of Scrap Iron & Steel, with approximately 1200 member companies alone; another, the National Association of Secondary Material Industries, with some 600 companies; and a third, the National Association of Auto and Truck Wreckers, with about 500 members. These are supplemented by regional and local associations and groups.

The work performed by these associations and their members is perhaps self-evident from the names, but let me outline this for you. Auto and truck wreckers, of course, are those who operate the vast acreages of auto graveyards seen throughout the nation today. These firms are in the business of selling parts from old automobiles and wrecks to persons who need them for repairs or who are looking for a more inexpensive way of obtaining a part than buying it new. They do surprisingly well as business ventures because capital investment is very small and overhead is practically non-existent. When all available parts are sold from the old clunker, then the shell is available for sale to the iron and steel scrap processor. More about this later.

The National Association of Secondary Material Industries includes within its membership firms which are non-ferrous scrap dealers, smelters and refiners of secondary metal ingots, paper stock dealers, rubber and plastic dealers, textile dealers, and firms engaged in handling wood pulps. Products covered by this group range all the way from reclamation of precious metals through hair and feathers. As you might well understand from this description, there is an extensive network of companies throughout the nation which specialize in a wide range of waste material products. Without them, these items would find their way to the dumps, incinerators, and land-fill operations, in quantities which would be wasteful and costly. For a further examination of the scope of this portion of the industry, I would draw your attention to a book entitled Industrial Wastes and Salvage by Charles H. Lipsett of New York City. There are 66 chapters in this book, of which the last 11 deal with salvage operations ranging from autowrecking through municipal salvage.

My own association, the Institute of Scrap Iron & Steel, is the largest segment of the secondary materials industry in terms of tonnage handled and gross dollar sales. Our members are the focal point of the collection of both ferrous and non-ferrous scrap prior to shipment to either steel mills and foundries, or secondary non-ferrous smelters.

Statistical data are a measure of any industry. In 1962, the ferrous scrap industry provided a total of 25 million tons of processed iron and steel scrap for remelting or for other industrial and chemical uses throughout the United States. In addition, the industry exported over 5 million tons. Both of these figures will be larger when final data for 1963 are compiled. Also as a matter of record, in 1961, the non-ferrous aspect of the business provided a total of approximately 2.3 million tons of the more common non-ferrous products. Of this, over a million tons represented copper.

Obviously, to provide totals of this nature, an industry must be fairly sizeable, especially when it is considered that much of the scrap must be collected from individual sources throughout the nation. Let me detail this for you so far as ferrous scrap is concerned. What we are talking about here is a total in 1962 of 30 million tons of processed ferrous scrap. Where did it all come from? (Incidentally, many of the sources for ferrous scrap will be the same as those for the non-ferrous items, with some exceptions.)

A sizeable portion of it originated with manufacturing plants. If there were no use for this material, it would wind up in discard and prove yet another disposal problem. As it is, a great portion of it finds its way back to the steel mills and the foundries, where it is melted along with pig iron to help make new steel. Last year, the Institute estimates that approximately 11 million tons came from industrial plants.

As for other sources, autowreckers provided another 4 million tons. Railroads generated 3 million tons. Demolition of buildings is estimated to have accounted for 3 million tons. Shipbreaking brought 500,000 tons. Farmers provided a million tons, while detinning operations and tin shredding accounted for 850,000 tons. Public utilities and government agencies provided about a million tons. The remainder came from a wide variety of sources, including individuals, non-manufacturing companies, second-hand dealers, and so on.

The peddlers and other types of collectors, the little junk dealer and junk shop operator, are the backbone of the collection of what we describe as obsolescence material. Our processor and broker members, as well as those firms in the demolition business, handle material from industrial plants and from demolition. Our dealer members purchase from government sources and the railroads, as well as from autowreckers. This flow of material to the processor represents a great saving of the nation's natural resources. In the non-ferrous end of the business, secondary scrap smelters, who produce secondary non-ferrous ingots, have a tremendous sum tied up in their smelting operations. On the ferrous side, our members, too, have large sums invested in equipment to process material. In some of our larger yards, capital investment costs, including balers for baling automobiles and light sheet iron, hydraulic guillotine shears for cutting scrap into furnace-sized bites, and a multitude of other specialized equipment and buildings, runs well over a million dollars. In smaller yards, the investment is proportionately lower, but it is much larger than the average person would assume. The least expensive guillotine shear, for example, costs about $50,000.

Let me stress again the importance of the salvage industry in reducing the volume of solid wastes that flows into dumps, land-fills and incinerators. I stress this because we have begun to run into some serious problems with urban renewal authorities. Failure to recognize the true role which the secondary materials industry plays in a community has meant that in many instances when an area is opened for urban renewal and when industry is permitted to return to the area under the new planning, no provision is made for the return of the salvage operator. This is because it is assumed that salvage operations perform no real and valuable function in the community. It's assumed that salvage operators can exist elsewhere, and perform their functions just as well. But while this may be true in some instances, it is not true for the majority of cases. The cost of handling and the prices paid for the processed material do not permit of too much rehandling or long-distance hauling. Salvage operations should be permitted to continue in areas of light or heavy industry providing they meet with the standards established for other industries moving back into the area. I have seen many examples of scrap processing yards which were not recognizeable from the front because of good screening and fencing. Salvage operations are necessary to industry. They are actually necessary in handling the more more tangible cast-offs of our every-day living. They may not be the most attractive sights in the world, but then no one is going to admit that a sanitary land-fill, an incinerator, or a dump, are the most pleasant things to have around.

I wish that I could take the time here today to describe fully how ferrous scrap is processed in one of our member yards. But let me give you a brief description. I believe the baler is a familiar sight to all of you--it makes a bale of steel scrap from an old automobile or light sheet iron, which is about the size of a modern-day TV console set. The guillotine shear, which shears railroad car sides, girders, old automobile frames, and so on, is exactly as its name describes. Material flowing in unprocessed form into the yard moves through these various pieces of equipment and out the other end of the yard in railroad cars destined for the steel mill or foundry where it will be remelted.

Non-ferrous scrap is segregated from the ferrous material either at the start when it comes into the yard, or during the processing operation. It is further segregated, cut, and baled in the metal warehouse--virtually the only operation which takes place indoors. A ferrous scrap processing yard is actually a factory without a roof and its operations truly termed an iron mine above the ground.

There are specialized operations around the nation in which I believe you will be interested. Let me cite one in particular--this time in the non-ferrous field. Up at Calumet, Michigan, at the site of the Calumet and Hecla Copper Mining Company, there is a copper leaching operation which makes use of scrap. In a large building are gigantic vats approximately 40 to 50 feet across and 30 to 40 feet deep. Into these vats are placed quantities of copper scrap, including copper plated wire, old motors, and other scrap items which contain copper. A solution of ammonia, copper sulfate, and carbon dioxide is circulated throughout the material as it lies in the vats. The process is fairly lengthy--taking up to two months in some instances. Just as long as the liquid coming off the vats after circulating contains more copper than that going in, the leaching process is still in operation. As soon as a balance is reached, all of the freely available copper in the vats has been leached away. What remains is steel or iron scrap. I have seen motor armatures which went into the vats loaded with copper coming out completely clean, with the steel scrap available then for shipment to the steel industry. The purpose of this operation is to obtain copper for smelting. Steel scrap is a by-product.

I mention this operation because there is need for additional research in this area. Copper in steelmaking is a growing problem with the steel industry. In certain types of steel, copper is a welcome addition, but in others it presents production problems that are difficult and costly to handle. Because of the difficulty in removing copper from many electrical items, it is not economic to process it by hand. If there is any steel attached to the item, it generally winds up on the steel scrap pile or on the dump. What is needed is an easy and fairly efficient manner of removing copper from a wide range of items so that nothing is left but steel, while the copper residue from the operation can be sold separately.

As it is today, the presence of copper-bearing items in steel scrap has presented us with serious problems. The steel mills will just not take this kind of material. Old refrigerators and stoves, radios, TV chasses and the welter of other things of an electrical nature which form such a large part of our modern-day civilization are being dumped. They are adding to the problems of municipalities, and they are wasting the natural resources which each of these items represents.

The leaching operation I have described is one answer, but as you can gather, the scale in Calumet is much more vast than anyone could possibly handle in the scrap industry. Land alone would be a tremendous problem. I understand some work has been done in this area by Monsanto, and it may well be that further research will turn up an easy and relatively inexpensive solution which would help clear up this problem and would reduce the flow of this type of material to the dumps and elsewhere.

Let me describe another fascinating operation because it touches on one of the biggest wastes in the nation, and one of the greatest problems for municipalities. In Los Angeles we have a member company called Los Angeles By-Products. This firm operates a unique plant which covers a large city block. Into the yawning maws of its two-story deep chutes is dumped the hard garbage of the city, including tin cans, bottles, and other solid waste items. This material flows down to moving belts over which a team of pickers presides to remove the larger items, such as bedstands, lamps, and so on. The tin cans and the glass travel by inclined belts to higher levels where the ferrous material--principally tin cans, is removed by magnetic separation. The bottles are picked over, good ones going into cases, the others, if suitable, sold as cullet, or scrap glass, to make new glassware. The tin cans pass through a flame furnace, described as a popping furnace these days because it pops the pressure cans. The furnace burns off the paper and burns the residue. The material passes over a shaker screen where the dirt is cleaned off, and the cans pass into a shredder, where they are shredded into small pieces. Another cleaning operation follows before the material is loaded automatically on cars for shipment to the copper industry where it forms a basic material for removing copper from copper mine waters. There are one or two other plants of a similar nature in the West, but nothing like it in other parts of the nation, especially in the heavily populated East.

The ease with which these particular plants gobble up tin cans points up the serious problem which exists with regard to this type of solid waste in other parts of the nation. Unlike ordinary steel scrap, tin cans are not used by the steel mills except in very small quantities. The culprit is the thin tin deposit on the cans, which even incineration does not remove. Tin is another completely unacceptable item in steelmaking because when it goes into the steel as a residual alloy it forms hard spots and creates other difficulties in the rolling process. Small amounts can be tolerated, but the amount contained in tin can scrap makes this product a sheer waste. When one considers the vast amount of tin plate rolled each year in this nation, and the tin cans that are produced from it, one has some concept of the volume of natural resources involved here, and the weight of the problem presented to municipalities. In some instances, tin cans have been fed sparingly into the scrap, but I believe I am correct in stating that presence of tin cans in scrap today means the scrap is subject to rejection by the consumer.

There are detinning operations around the country, and successful ones, but these work solely with new tins and tin can clips from tin can producers. They do not operate on tin can waste because of the economics of cleaning the material. What is needed is some easy and feasible way for handling tin cans to remove the thin tip coating so that the remaining scrap could be utilized in steelmaking.

Part of the problem, too, is that tin cans are soldered, and lead and tin contained in the solder presents a further difficulty. Perhaps research in this area can point the way to a solution to this problem.

Recently developed by the scrap processing industry has been another operation which takes the principle used in shredding tin cans, beefs it up, and applies it to automobiles, refrigerators and stoves. Called the Proler process after the name of the developing company, this is basically a gigantic shredder which tears whole automobiles apart--less the motor block which is cast iron, and the radiator--and after magnetic separation and burning, produces a product which is low in residuals, including copper, fairly uniform in size and density. This has found excellent response in electric furnace steelmaking, where cold scrap is charged into the furnace, the electrodes are dropped and electricity does the job of melting the scrap back into steel. Unfortunately, the cost of these machines is great, by ordinary standards in our industry. I have been told that a complete installation costs well over a million dollars. Understandably, not too many of these will be built around the nation, although there are at present four in operation.

It may well be that the entire scrap industry will have to move in this direction to provide a product which interests the steel mills in scrap once again, because, believe me, our industry needs something. It sounds fine for me to talk about the size of this industry in terms of the tonnage we ship to the steel mills every year, but let me tell you here and now that we have serious problems in getting the steel industry to accept as much of our product today as we did just a few years ago. This year it is likely that the domestic steel industry will operate at close to 110 million tons of ingot steel production. In past years when this level of steel output occurred, the scrap industry provided up to 40 million tons of material for remelting purposes. This year, we will be lucky if we ship 28 million tons.

The reason lies in new basic steelmaking methods now being widely accepted throughout the steel industry. These involve special vessels which use oxygen in steelmaking, and which so far, have limited ability to consume scrap. The scrap they need for the process can be obtained right within the steel plant, and there is no need for outside scrap.

Similarly, steelmakers have changed their methods of making steel in the old standard open hearth. In the past, pig iron and steel scrap were charged in about equal portions to make a ton of new steel. Today, the domestic steel mills, making use of pelletized ores, and foreign ores, have been able to step up their production of pig iron from available blast furnaces, and with this increased production, they have been able to find ways in which the charge of pig iron or hot metal in the open hearth furnace can be increased. In some areas, instead of 45 to 50 percent scrap use, the charge has dwindled to 35 to 40 percent. The average charge of scrap in open hearth furnaces last year, for example, was 40.3 percent in contrast to 45 percent as recently as 1956.

This decline in scrap consumption is of great meaning to anyone who is concerned about solid waste disposal because the impact of the decline is falling into the obsolescence scrap area, rather than into industrial or demolition scrap. Old automobiles are a prime example of what is happening. Formerly, these were baled into a product known as No. 2 bundles. And virtually all the cars that came off the road eventually found their way into this product. But I am sure that all of you are aware of the burgeoning autowrecker yards around the countryside and the steep rise in the number of old automobiles which clutter up city streets. In New York City alone, 250 cars per week are abandoned. Normally, these would find their way into autowrecker yards or even into scrap processor yards. But increasingly this no longer holds true. I have a member in Washington who absolutely refuses to take in old cars. He has no market. I have been past other member yards in the District of Columbia where old cars which have been refused by the processor are left lying in the street.

Many of these vehicles wind up on the dumps along with the refrigerators and stoves which many dealers are unwilling to handle any more. We have a little junk dealer near my home in Bethesda, and a sign of the times is a hand-written notice on his gate: "We Can No Longer Accept Refrigerators or Stoves." His processor will not accept them from him, and if he prepares and ships scrap to the local mill, this material is no longer acceptable in any form.

As a result of this slowdown in steelmaking demand for scrap, more and more of this material is finding its way to the dumps. This is presenting problems for everyone, and as I have said, represents sheer economic waste of valuable metallic resources which we should not permit.

Our industry recognizes the problems which this shift in scrap consumption presents. By nature we are savers: it grieves us to see this material go to waste because we know there is use for it if economical ways of handling it can be found. We know that we could save municipalities and others considerable sums if the market could be opened up again. We are ready and anxious to do the job if it can be handled in such a way that we can process the material and stay in business doing it.

Research in steelmaking can provide some of the answers to these problems. Research in cleaning deleterious metals from steel scrap perhaps can give us other answers. If there is one area which has not been researched enough, it is the salvage area. There is room for a great deal of work, and I only wish that our association could find the dollars to do it. Currently, we are working with Battelle Memorial Institute, with the Bureau of Mines, and with the Department of Commerce. But we would welcome any additional research help in the areas I have outlined for you.

(General Discussion starts on following page)

GENERAL DISCUSSION

CHAIRMAN MC GAUHEY: Mr. Story certainly presented a challenge in opening up the subject on the matter of salvage. I would now call upon the audience to get into the discussion.

QUESTION: At the Phoenix Plant they have a salvage operation in which they sold scrap paper, rags and tin cans. When they got into production, however, and got some paper down to the paper dealer, he would not take it because he said it was too dirty. Also, when they got to the matter of rags to be collected, they found that there was a misunderstanding, that the rags had to be shipped to the San Diego works, which made it impossible because of the cost. Regarding rags, is it necessary to sort them into the various fabrics and to pick out the synthetics?

MR. STORY: The paper industry only now is beginning to recover from a recession which they had. The mills began to complain about the grade of paper they were receiving, and they swung away entirely in some instances from waste paper. Some of them set up their own waste paper operations in order to obtain paper of a more uniform size and type, cleaner and better segregated. The quality requirements from the mills are much stricter than they used to be ten years ago.

Regarding the rags, I must admit that I am not too familiar with this business. I have been confined primarily to ferrous and non-ferrous metals but in my reading in the field I have found that synthetics are a real problem and should be segregated. In Britain they overcame this problem by having what you might call rag sorters. These people will sort the rags out and do a reasonably efficient job. However, to my knowledge, in this country we do not have too many of these people. I have seen operations where women are sorting the rags into two or three different grades, but then it becomes a costly operation and I believe that the source of the rags must be reasonably uniform in order to make this worth while.

COMMENT: Tire casings are likewise a big problem. In other words, they are not good for sanitary fill and evidently nobody will take them.

MR. STORY: There is not a complete disposal operation for tire casings but there are a number of tire operations around the country where they will take reasonably good casings for recapping purposes, and there are some smaller operations around the country which will actually reclaim the rubber. We have one member in Chicago, for instance, who ships out three or four carloads per month of tires which he takes off of old automobiles that come into his plant. He did not tell me what his market was because he did not want the information to go out, but then he does have a market for them.

COMMENT: There is probably no market in Southern California.

MR. STORY: Probably not. Most of it is concentrated in the Midwest area--at least to my knowledge. However, burning is the real problem, especially in California.

COMMENT: Salvaging is not a static business. It is changing all the time and there are very many factors that can have a very pronounced effect upon it. In the last few years, we have been salvaging tin cans, one of the things that has had a pronounced effect on the salvage business was the saving at the source of some twenty percent of the metal used to make a can. We are not collecting as many cans now, on a tonnage basis, as we were a while back and it is due to many factors. But the one mentioned above can change the complete complexion of the salvage business. Therefore, we have to think in terms of the effects that these changes might have in a very short time. Should a city make a large capital investment in a business that is likely to change as rapidly as this does?

In a joint venture with a certain company, we have taken non-combustible rubbish as collected. The rubbish is steadily declining while the steel component is going up. Two and a half years ago we stopped delivering glass and only deliver metals in the form of salvage. For these we received a much higher price than for salvage previously including glass and other non-combustible rubbish.

COMMENT: I think that we should find out where we are going--the kind of products that are going to be in the rubbish in the future. For instance, there is the influence of plastic containers on rubbish disposal. I think that this is going to become an important area for research.

You will remember that the refrigerator made a big difference in the rubbish collection business, especially when salvaging garbage was considered quite important. Then the frozen foods came in, and of course, the preparation of food in tin cans has had an effect. I believe that these things are going to continue to happen in the future and perhaps faster in the future than they have in the past. They are going to play an important role in the functioning of the disposal industry.

MR. STORY: Of course, we do have a problem with glass. It used to be that there was a market for most of it in our industry. They used to use cullet as a raw material just as the steel industry used scrap as a basic raw material. But, today they have largely swung away from this. They are selecting from specified areas and only from certain types, and they would prefer to use their own raw material. The result has been a decline in the glass market. I don't follow the cullet market, but there are trade publications that quote the prices, such as The Waste Journal, which is a weekly tabloid, followed by a monthly publication, which quotes prices for a wide range of products--all the way from scrap iron down to feathers and hides.

COMMENT: I am from Baltimore. No doubt you have seen some of our automobile graveyards. There is a good one at Bailey and Washington Blvd. that covers many acres and has been very highly criticized by the U.S. Public Health Service as being a home for rats. All of our zoning people, planning people and health people say that the rats should be eliminated and that the only way to do this is to get rid of the automobiles. But nobody wants them, so we are left with a big problem.

MR. STORY: That is the very point that I was attempting to make. There is no uniformity of approach to this problem. One part of the Public Health Service says that these are rat breeding areas and we should get rid of them and then another Public Health agency asks that research be undertaken with regard to incineration for automobiles. They say that we have to get rid of them, but then the steel mills do not want them.

COMMENT: It seems to me that we should first direct our research efforts toward separating the mixture and mess of rubbish. It has already been broken down into particular categories. Now, if research cannot classify or clean up each one of these categories sufficiently to allow them to be reused in the current markets, then research should be directed toward developing new products.

QUESTION: Does your institute or any of the other scrap industry institutes support research for conversion and processing of scrap material?

MR. STORY: We do what we can with the limited funds available to us. As I mentioned, we are working with Battelle, We are working with the Bureau of Mines and with Commerce. We are trying to find additional money to do further research but we have been unsuccessful.

Most associations, unless they consist of relatively large units and companies which can come together and find funds for research, do not have these funds. In our group, we are the most active of three associations, and our expenditures do not exceed $10,000 annually. Let me tell you what we have done. One study, by Battelle Memorial Institute, was to define or delineate the problems in the scrap industry and determine methods to eliminate them. We had another research study on the metallurgical characteristics of the No. 2 bundle to determine how much ferrous material is in it, as well as the copper, brass, lead, tin, and other things, so that we could be able to show the mills exactly what the constituents were in this product and they could use it more readily.

The current research project which we have and which is a joint project with Battelle and about thirty other companies, is directed specifically to the new types of steelmaking methods and what the impact of these will be on the various supply industries.

Our work with the Bureau of Mines is concerned with the recognition of alloys and the possibility of segregating alloy steels. Actually the steel mills do not want to take scrap material from us unless it is absolutely pure, and yet they make products into which they put lead, copper, you name it. We are also into the matter of increasing the use of scrap in the basic furnaces. The study with the Department of Commerce concerns mainly economics--a wholesale study of the value of the scrap industry.

The area of new use is likewise important. We had one small study in which we found that certain grades of scrap could be used in concrete shielding for atomic reactors. However, the Atomic Energy Commission does not desire to use scrap punctures--they would prefer to buy the steel plate and make the punctures themselves. The material is called ferro-concrete. We tried it on roads. It contains pourings and turnings which are no longer used in blast furnaces to any great extent. They are being thrown on the dumps to rust.

COMMENT: I get the general feeling that this whole picture seems to be moving from one in which there is an economic feasibility for the salvage industry into one in which the reject sort of moves into the public domain. You mentioned the problems with automobiles, refrigerators, brass pourings, and machine tool turnings ending up on the dump. All of these are things which formerly went into the salvage industry and then back to the mills. But because of the low return from many of these things, it all seems to be moving toward the area where this becomes a public responsibility.

MR. STORY: Actually, there is another segment of the waste industry which is not a public responsibility--the private collectors and trash haulers. It is interesting to note that many of our companies have diversified into trash hauling. There is one large nationwide organization of trash haulers and there is another detachable container association that has been formed. I think that fully ninety percent of these people are members of one or the other of the two associations.

Of course, I do not want to leave you with the impression that all is lost. I would not be in this industry if I thought it was going to go down the drain within the next five years. I believe I am correct in saying that the impact of the problem has been felt by municipalities progressively over the last five years, and as far as I can tell it is going to continue for at least another five years before there may possibly come into effect some counterbalancing forces that are already in operation.

The first, of course, is the shredding. Shredded material has not been overly successful in open hearth operations but it does permit a fairly fast charge because it is small. There is also another kind of oxygen steel-making furnace that was introduced in this country and which has been in operation for about a year. It has a scrap using capability of 40 to 50 percent. They are having lining problems right now; the refractory brick is not living as long as it should, but these will be overcome.

We believe at the present time that those mills which are not integrated, which have electric furnace operations and take scrap as basic raw material, will be able to remelt it, adjust the chemistry, and bring out a finished product. Of course, the fact that the price of scrap is low inhibits the collection of scrap and this we do not like. We feel that if the price of scrap were five to ten dollars a ton higher today that the collection would step up. I am constantly hearing from our members that collections are off--they cannot make any money--the scrap isn't coming into the yard. However, they are talking primarily about the non-ferrous scrap. We would find that if the price were up a little bit that we could pay more over the scale and this, in turn, would step up the collections and bring more material in.

In addition to these methods there is also, in American steelmaking, the continuous tinning process. I don't know whether you are familiar with it, but in making steel we first start off with pig iron. This runs off the bottom and then is taken in hot cars to the steel furnace. It goes into the steel furnace, where it is refined into steel. The steel is then tapped into ingot molds. After molds are lifted off, the ingots go into a soaking pit, where the heat is increased. They soak up heat in there and are brought up to rolling temperature. They are then taken out of the soaking pit, which is underground, and moved into the breakdown mill where, if you get a continuous rolling operation, the steel is rolled progressively thinner into a sheet.

Continuous casting is entirely different. In continuous casting, the iron comes from the blast furnace and goes into the steelmaking furnace. Then you have a continuous casting machine. It eventually goes into a reducing mill, where it is reduced into a sheet and from there on the process is the same. In the latter process, however, you do eliminate several of the stages indicated in the first example.

Now, after each one of these stages there is a scrap loss--as much as 25% in a ton of steel. In other words, the yield is 75%. But in the continuous cast process, the yield is about 92%. This means that you have that much less scrap. We are hopeful that the continuous casting operation will help cure the current imbalance which has occurred in the scrap situation, and that it will also help to cure our problems relative to solid waste disposal.

In connection with this, we will have to find economically feasible methods that will enable us to get rid of the copper problem because the steel mills cannot stand it. The Copper residual in all steels is building up and thus reducing the workability of the steel. Therefore, as you can see, there is a need for work in this area. And if my forecast is right, I would say that within five years we will be swinging back into some kind of balance.

No doubt you have heard of the contemplated increase in family formations which is getting under way now and which is scheduled to constantly increase over the next ten years or so. If these forecasts are correct, then this is going to mean more refrigerators, more stoves, more hard goods of all kinds and this likewise will increase steel production requirements. It will also mean that more scrap will be needed to support these operations and, at the other end, more headaches for you and for all of us.

COMMENT: It seems to me that you have come up with a situation where there is going to be a greater integration of the public function and the private salvage operation--a tremendous materials handling situation.

There is also a classification problem but economically, when you attempt to do this on a very small scale, it just doesn't balance out unless you are operating with an individual family on a very marginal basis. Thus we are moving into a situation where the public function and the salvage operations tend to get closer linked together in order to raise the level of the whole operation.

CHAIRMAN MC GAUHEY: One of the things that impressed me as we come to the close of this particular subject is that the avenues for research of this particular subject seem pretty difficult to define. It has been pointed out that we need to look into the possibility of new materials --what is going to be the changing nature of the solids which might be salvageable. We also need to get at this matter of proper materials to meet the very clearcut trends for steel industry scrap requirements. Nevertheless, this matter of salvage is not totally closed and as we proceed we will undoubtedly find the subject coming up as we discuss agricultural wastes and other things.

Processing Agricultural Wastes

Samuel A. Hart
Associate Professor
Department of Agricultural Engineering
University of California
Davis, California

Wastes are an inevitable by-product of all of life's processes. Since wastes are so inevitable, we cannot ignore them, but must expend effort to dispose of or to reclaim them.

The wastes of agriculture often are overlooked--until irate suburbanites complain of flies or odors from nearby farms. The nature and the magnitude of rural wastes are the subject of a current paper (1)*; two of the wastes--livestock manures and field crop residues--are produced in such quantities, and are such degradable organic material, that their management is a serious problem.

Sanitation requires that wastes be managed. The major sanitation problem with manures and with the residues of many field crops is the control of houseflies, fruit flies, stable flies, and most of the other flies of public health hazard and public health nuisance which breed in moist organic matter. Additional considerations are the prevention of disease, efficiency in carrying out farm chores, odor and dust control, and aesthetics.

The Feedlot Problem

We can appreciate better the nature of agricultural waste management and the need for processing if we look at a particular operation. The manure wastes from cattle feedlots pose a problem typical of nearly all of agriculture's discard dilemma.

Feedlot finishing of beef is almost universal practice today, practically all cattle spend the last 3 to 5 months of their 18 to 24 month lives in feedlots. There they are confined to approximately 100 square feet of corral space per animal, and are gorged with rich and nutritious food, all certain to turn into tender and succulent steaks--and manure. Thus by-products of feedlots are flies, fly breeding, odors, and manure dust. Since the suburban sprawl of recent years has brought high-cost human housing up to the corral fence, feedlot nuisance cannot be tolerated.

At the same time, manure disposal opportunities have become bleak. Today's technological prowess enables us to make concentrated fertilizers from rock, petroleum, water, and air, and to make them cheaper than the cost of hauling and spreading manure.

Even where the livestock farmer is willing to subsidize manure use, he is faced with an additional problem--the crop farmer who would use the manure wants it only at land preparation time, in the fall or spring. But animals defecate at all seasons. A few years ago the feedlot operator could let the manure accumulate within the corral until it could be sold. While waiting, he would mound it up so the animals could climb on it in wet weather, and so they could have a better view of the quiet countryside. However, sanitation demands, often through edict or regulation, have begun to change this. More and more feedlots now have to be cleaned out monthly, or even weekly. Often this manure is spread on fallow land. This only transfers the problem from feedlot to field; it solves nothing. If the haul is distant, or the field wet and impossible to spread upon, alternate disposal methods are necessary, these may involve processing as conventionally interpreted.

Processing is the second of three steps, or unit operations, in the management of agricultural wastes. Processing is preceded by collection, and is followed by utilization or disposal. It should be useful to review the methods of manure processing used today, and those which may offer some hopes for the future.

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* Numbers in parentheses ( ) refer to the appended references.

Storage

Storage is time changing or conversion. It is usually the cheapest and, in many cases, is an adequate method of processing manure for sanitation's sake until it can be used.

The largest manure-storing operation today is that of the Dairyman's Fertilizer Co-op, Inc., near Los Angeles (2), involving 200 dairyman members owning 50,000 cows. Manure from their feeding yards and corrals is cleaned out weekly and hauled to the stockpile, just 18 miles from the Los Angeles City Hall. A bulldozer spreads it onto a 50-foot high manure mountain for consolidation and drying. This manure pile covers 4 acres of land and contains 400,000 cubic yards--about one year's accumulation. Three full-time salesmen sell the manure, mostly for citrus, vegetable, nursery, and highway landscaping use. The selling price does not pay hauling and stockpiling costs, but this is still the least expensive system these dairymen have been able to devise for getting rid of the manure.

Some research work has been done on manure storage (3). Tarpaulin covers for short-term storage prevent fly production but do not improve the manure. Plans have been developed for a flytight storage bin for holding poultry or dairy manure (4), and variations of it have been built by poultrymen.

Because of the economy of storage, it will continue to be a common method of processing manure. In addition, storage will always be an adjunct to any other method of processing.

Drying

Drying is a satisfactory manure processing technique because it stops biological activity--both attractiveness to flies and the degradation that occurs in wet manure. In addition, drying reduces the weight, and often the volume, making hauling and use more feasible.

Artificial drying is not a very promising method, because of cost. Ludington estimates that poultry manure would have to sell for 1 to 1-1/2 cents per pound to pay the cost of drying it. Sun-drying is possible in the West, and should be possible in any area where hay or other crops can be field cured. Natural drying is speeded by stirring or spreading thin. Several studies have been made on such drying (3, 6, 7, 8), all with quite satisfactory results.

Although drying--and necessary storing--will be more expensive than storing alone, the dry manure will have greater value, so the drying may pay its way.

Composting

Composting, much praised for processing organic wastes, has been advocated for livestock manures (9, 10). The moisture content at which manures will compost satisfactorily is rather critical; freshly collected manures often are too wet. If so, they must first be dried partially, or a dry filler added (11). Manures have a carbon-nitrogen ratio between 8:1 and 12:1 (12); often there is not enough carbonaceous material to supply the necessary energy for biodegradation to humus form. Composting of pure manure then results in the loss of some nitrogen or in incomplete stabilization. The value of carbonaceous filler materials to aid composting is obvious, and suggests the desirability of combining municipal solid wastes with livestock manures.

There are some practical limits to composting manure on the farm. The farmer usually is not interested in or capable of running a full-scale compost operation in conjunction with his regular farming. In fact, one of the principal reasons we have agricultural waste disposal problems is that farming is so specialized--one farmer grows only beef, another only wheat, and so on. It well may be that composting, to become an important processing method, will have to be done at a central location by a cooperative or by private enterprise that can serve other segments of society in addition to agriculture.

Digestion

Anaerobic digestion has received rather thorough research as a method of stabilizing animal manures (12, 13, 14); these laboratory studies indicate digestion to be technically feasible.

Satisfactory loading rates were found to be similar to rates for conventional municipal sludge digesters--9.10 pound volatile solids per cubic foot of digester capacity per day, and month-long detention at 95° F. Except for dairy manure, gas production per pound of volatile solids destroyed, pH, percent reduction on volatile solids, and other parameters of operation were similar to those of municipal digestion. Dairy manure did not undergo nearly the biological breakdown expected of its high organic content. Since this is a waste from a ruminant animal, in which the readily available energy was removed by anaerobic digestion within the animal's stomach, the waste is not amendable to much further breakdown.

Several factors militate against digestion as a practical method of processing livestock manures. Digestion equipment is quite expensive and complex. Digester operation takes time and know-how, and the farmer is not likely to want to become involved in it. Most importantly, fresh manure, typically 30 to 50 percent solids as collected, must be diluted to 8 to 10 percent solids to work well within a digester. Digestion does reduce the amount of total solids, but the volume of sludge to be dewatered and the volume of supernatant are greater than the original manure.

Lagoons

Many livestock farmers, having decided that it is uneconomic to expend any effort on manure, are interested only in immediate and outright disposal. "Manure lagoons" are one such approach. The manure is dumped into a pond or water-filled sump; biological activity is supposed to reduce the manure to an insignificant amount of sludge, and to do it without attention, odor, or nuisance. Naturally, it has not worked out so ideally.

Lagoons have had their greatest acceptance in the Midwest, on hog farms (15, 16). These lagoons are generally designed at 15 square feet of surface area per hog, and are usually about 3 feet deep. The term "lagoon" is a decided misnomer; the loading rate is approximately 1300 pounds of BOD per acre-day, greatly in excess of conventional sewage "lagoons," in which the loading rate is 50 pounds of BOD per acre-day or less (17, 18). In true fact, these manure lagoons are unheated, open-topped, anaerobic digesters. The loading rate, in more logical terms, is approximately 0.016 pound volatile solids per cubic foot of digester capacity per day. This is two-thirds the conventional loading rate of Imhoff tanks or unheated (but closed-top) municipal sewage sludge digesters (19). Research on manure lagoons at the University of California is concerned with the parameters of operation, including a materials balance.

Manure lagoons have been built by poultrymen. The present recommendation calls for 2-1/2 to 3 square feet of surface area per hen (20). These lagoons, too, are far from pristine.

Manure lagoons have not been satisfactory for the disposal of dairy and cattle manure. The lagoon effects little reduction in solids, and the large amounts of inert hay stems float to the surface to form a crust.

Occasionally, odors have been a serious problem with lagoons, but lagoons appear to be an acceptable manure disposal system for many farmers, and will probably continue to be used until ground-water pollution, excessive odors, or other factors force a change.

Other Manure Processing Methods

Some additional processing techniques for manure have undergone limited testing, or have been conjectured to have some potential.

Incineration has been appraised as a method of poultry manure disposal (5). Theoretically, poultry manure with a solids content of 35 percent or more will support its own combustion in a conventional incinerator. The Zimmerman wet oxidation process (21) could undoubtedly be used for manures as collected. As with other processing methods that require elaborate equipment, it is unlikely that farmers will operate such systems on their farms, but these are possibilities for an area-wide waste disposal activity.

The activated sludge process is aerobic degradation and stabilization in a water medium. Laboratory studies on the potential of this for highly diluted hog manure indicate that BOD reductions of 70 to 80 percent are readily obtainable (14). It is uneconomic to expect endogenous and complete stabilization, but activated sludge degradation of manure may have some potential.

Much of the larger particulate matter of manure is reasonably stable (22, 23). This suggests separating manure into two components--the relatively inert coarse organic material, and the fines and soluble matter. The coarse material would have a limited but shiny market potential in the nursery trade. The fines and soluble in the wash water would be susceptible to treatment by true lagooning or activated sludge. Again, such techniques may have a potential only on a combined or cooperative basis.

And finally, consideration has been given to converting manure into algae in high-rate, completely aerobic ponds, and then feeding the algae back to livestock. A recent evaluation (24) is that it is a procedure for the future, when algae harvesting techniques are perfected and the need for conservation through reclamation and conversion is greater.

Field Trash Processing Problems

Up to now this paper has dealt primarily with livestock wastes. The crop residue processing and disposal problem is nearly as serious, though of a different nature.

Cull and overripe fruits and vegetables left in the field, and all tree prunings, stubble, and unharvestable plant parts pose a difficult and expensive waste management problem. These wastes are generally disposed of in three ways: plowing into the soil, burning, and surface spreading.

Plowing the crop residues back into the soil, the most general method, is sanitary but expensive. A 2-way discing is usually necessary to thoroughly incorporate the residues into the earth. The degradation of soil-incorporated plant materials of low nitrogen and phosphorus content temporarily ties up these nutrients and creates fertility problems for the next crop planted.

Burning such residues as cereal stubble and tree prunings is simple, but adds to air pollution. It is prohibited in some areas, and wastes organic matter that ought to be incorporated into the soil.

Surface spreading of crop residues must usually be preceded by a trash cutter or chipper that reduces tree prunings, cornstalks, and other residues to mulch-sized particles. Leaving this residue on the surface may help erosion control but may harbor overwintering insects and fungi.

Collection is not a problem with field residues which are treated where created. Certain crops, however, such as lima beans and sugar cane, are harvested by removing nearly the whole plant from the field and then returning the trash after the wanted part is separated out. Spreading and preparing these wastes for incorporation into the soil is costly.

The sanitation problem of some crop residues is not so much one of how but of when. Perishable fruits and vegetables, such as tomatoes, melons, and deciduous fruits are harvested over a period of several weeks to several months. Inevitably some spoiled fruit from the beginning of harvest must just lie in the field, rotting and creating sanitation problems, until the whole crop is harvested and the trash is properly disposed of.

Wastes Management and the Future

Agricultural wastes--both manures and field trash--are not wastes separate from the rest of society's discards. Agriculture itself is a segment of our whole society, just as are municipalities and is industry. None exists alone, nor should the management of any one of the wastes be considered unrelated to the others.

As our population explosion continues, it will create pressures in which organic solid wastes, including those from agriculture, will have an important role. As the population inincreases, our level of sanitation must be maintained and improved so that man may live satisfactorily in closer relationship with his fellow man.

The land area producing food for the rising population will remain relatively constant. There will thus be greater opportunity and need to use processed organic wastes to aid in producing more food from the limiting land. There is little question but that the major sink or repository for much of our processed solid organic wastes will be upon agricultural lands. On the other hand, the farmer can use these organic materials only as they benefit him and increase his yields and profits.

Research is needed to anticipate this era of more complete utilization of organic matter. We need to develop techniques and processes that will enable us to combine and conserve solid wastes from all of society to utilize them economically for our greatest benefit.

GENERAL DISCUSSION

CHAIRMAN MC GAUHEY: Sam, you suggested the possibility of using the Zimmerman process for the treatment of manures. Does anyone desire to speak on that subject?

COMMENT: Richard Green of Washington State University has done some studies on lagoons, and maintains that this matter of digestion, contrary to our thoughts, is not so slow as it seems and that if you remove the manure in 2 days, the odor problem will not arise. It has to be carefully designed because if the period extends up to five days, let us say, then there is odor production. But if you go into the lagoon with low enough loadings, you might not have the problem.

DR. RAY: My predecessors at the University of Missouri did some work on this, but the water requirements are high. We have talked about the possibility of recycling and the concept of a lagoon which was what we might call a raised track type of thing and this, of course, requires power.

I also had a question. At one time one of the problems in municipal lagoon operation was on the harvesting of algae. What is the current status of separating the algae?

CHAIRMAN MC GAUHEY: We can separate algae in considerable quantity by centrifuging, but this is uneconomical as a practical scheme. The possibility of precipitation has not been totally ruled out, however, this method has not yet been resolved.

DR. HART: I have not done any economic analysis of activated sludge because I don't really know what the parameters of design for activated sludge treatment of livestock manures would be. I don't know what concentrations of manure we should have--one percent solids, two, or something like this. I don't know what the detention period should be. This is a technical research problem that could well offer the farmer a better method to get rid of manure.

COMMENT: I think that water could be added to move the manure hydraulically to the lagoon. The sludge could settle to the bottom and ferment, and the liquid portion, containing some finely divided solids, would be carried on. I would not put the solids in an activated sludge process. I have seen no fermentation in any of these manure lagoons, unless something is done to promote it, and if this is done you have no stabilization.

PROF. DORNBUSH: We have been involved in some work with lagoons for the treatment of poultry wastes--rather small ones serving ten thousand birds. Methane was generated quite effectively. Three lagoons that I observed seem to be very effective. They did not collect gas, but boiled instead, and there was no odor during the period from May until October. During the winter the temperature is down to the point where there is no biological action and, as a result, no odors.

PROF. AGARDY: I read an article in a California paper about a medical experiment in one of the prisons. They were feeding a liquid diet to convicts to see whether they could subsist on a synthetic food. One of the things they noted was that these people produced about one-fifth of the normal amount of fecal material. Has there been perhaps any work with livestock to determine whether a synthetic diet would reduce the amount of waste that you would have to handle?

PROF. MORRISON: Much has already been accomplished on this. Compare grazing, for example, to a feed lot operation. A good share of the feed is now pelletized, and does reduce the amount of manure. Insofar as using a synthetic diet, all you are doing is adding the economic burden at one end of the line to effect a saving at the other end. A certain volume of bulk is required in order to maintain digestion. Therefore, I am sure that some progress can be made in this direction, but it will not completely solve the problem.

I am a microbiologist, and have listened to many of the comments on composting and on attempts to ferment waste materials. Other countries have done this. But today it has no value, because it cannot compete with the synthetic chemical industry. Some attempts have been made to upgrade the value of the end product of fermentation. An example is the corn starch industry. Up until the forties, they were steeping the corn, floating it over the starch. The rest was going into the river, creating a horrible nuisance. However, along came the idea of fermentation of bifungi for antibiotics and all of a sudden a new industry was created.

Another example of waste upgrading has to do with something that you would consider valueless. If anything is less valuable than horse urine, I would like to know what it is. This is probably less valuable than cow manure. However, in the early work with steroids and their effect on human reproduction and other body mechanisms, someone took a look at horse urine--from the stallion and from the pregnant mare. Suddenly this was a valuable product, at least for a couple of years, when they were extracting steroids. Other sources have now been found, but for a while horse urine was a big thing.

I am not convinced that we know enough about cow manure. We know about the carbon, hydrogen, and a few other compounds, but what about some of the trace substances which may have some value? I believe that this is an area needing a tremendous amount of research.

MR. KENNEY: I have read that in Eastern Pennsylvania they turn all of the manure back into the soil. Is the problem in California, then, one of concentrated volume?

DR. HART: That is basically right. Years ago, the farmer had his fields as well as his livestock and had maybe only twenty or thirty cows. Today, however, a dairy may own 200 to 500 cows and keep them on six to ten acres. It has become a highly commercialized business.

MR. GILBERTSON: I believe that the new U.S. Department of Agriculture program on urban planning and development is symbolic of the trend that is taking place. In the Huntsville, Alabama area they have just, within the past two or three years, gone into a country-wide solid waste program, which includes the whole rural area as well as the urban area. Due to packaging changes and other things, the farmer has a problem just like the city dweller.

CHAIRMAN MC GAUHEY: I believe that everyone here will agree that we have had a very rewarding and stimulating discussion. Let us now adjourn.

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Conservation and Field Testing of Compost

Dr. Cord Tietjen
Agricultural Research Institute
Braunschweig-Volkenrode, Germany

Where difficulties are encountered in getting rid of increased quantities of organic wastes, composting suggests itself as a means to utilize these wastes on a commercial basis, by transforming them into a salable product. Unfortunately, it has been the fate of most compost products to be introduced on the market, only to disappear shortly. One reason may be that with the inclusion of bargaining, the situation for farmers and gardeners is essentially changed, since the composting of farm or garden wastes is a traditional, more or less carefully executed process with little attention being paid to the expenditures involved.

While at present "composting" ranks with incineration and sanitary landfilling as a method of refuse disposal in many countries, it must be realized that three groups of persons ordinarily participate in the composting of refuse:

1. the producers of solid wastes and the officials and boards responsible for providing sanitary collection and disposal facilities;
2. the inventors and builders of compost processing equipment, and the compost producers;
3. the farmers and gardeners who are the expected buyers of compost products.

The difficulty of balancing the economic interests of these groups has been clearly demonstrated. In this respect, the Netherlands is well known as an outstanding example of a case where the three groups found the modus vivendi. It must be remembered, however, that in the Netherlands, production and application of compost from town wastes is an age old tradition. (The Netherlands also ranks first in the world in the rate of mineral fertilizer consumption.) This tradition has made it possible to overcome difficulties and prejudices, but to establish such a tradition requires cooperation, persistency, and convincing proofs. The producers of machinery and compost products can scarcely be considered competent to adduce convincing proofs; but certainly they will support cooperative work by the responsible officials and the landowners in finding solutions to sanitary waste disposal and soil fertility problems that satisfy both parties. This makes it necessary to:

1. examine and test composting machinery, processes, and compost products,
2. establish sanitary requirements,
3. demonstrate the use of compost under controlled field conditions,
4. evaluate quality claims.

Anderson (1)* stated in 1958 that the economic potential of composting is not great, however, "it is expected that in some places a measure of economic success may be experienced."

We realize that since the problem of waste disposal is steadily increasing, composting can be a solution, if it is possible to use compost products to improve soils and increase crop yields without financial loss to the landowner. There are areas where the application of refuse compost can compete with other means of re-establishment and conservation of soil fertility--in Germany, for example, to prevent water erosion in viticulture and fruit-culture and in the reclamation of waste land, or in areas where mines have been closed or shifted. The recent work of Kick (7) is noteworthy as well as the successful work of Schurig-Markee (22) in applying raw refuse from Berlin to his 5400 acre farm. After 25 years of experience, it was reported in 1939 that: "The great quantity of refuse (178 tons per acre and more) changes the soil structure totally. Light sandy soil and somewhat boggy soil become more cohesive, their water capacity is increased, the disagreeable blow away by strong winds ends. . . . With heavy loamy soil the effect is just the contrary. Refuse loosens and makes the cloddy or sticky soil crumbly, thus facilitating the cultivation very considerably."

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* Numbers in parentheses ( ) refer to the appended references.

The three most important requirements concerning compost quality are:

1. an absence of substances that are injurious to man, crops or soil;
2. a high content of organic matter and plant nutrients;
3. a low content of useless substances like stones, slags, fragments, and plastics.

Because additional sorting and sieving are necessary to lower the content of useless substances, costs are increased in producing special grades of compost. Therefore, cost saving gradations are usually made according to the purpose of applications. For example, quality demands are less for re-forestation areas than for woodland areas; they are higher for viticulture and fruit-culture, still higher for agriculture, and the highest for horticulture and pasture farming.

Thus several quality and price gradations should be considered, i.e., for inexpensive compost to be used on wasteland that is being reforested, and for better grades of compost (free of splinters) that may be used on pastures and in gardens. If the product is to be used in agriculture, assuming that sorting and sieving are done with the necessary care, different gradations are produced according to the particular processes of composting utilized. Without discussing the various methods in detail, some gradation possibilities are illustrated in Figure 1. The schematic drawings represent three composting methods that are in use in Germany--at Baden-Baden, Heidelberg (Dorr-Oliver), and Kreuznach (Dano). They have been described in detail by Wiley (20).

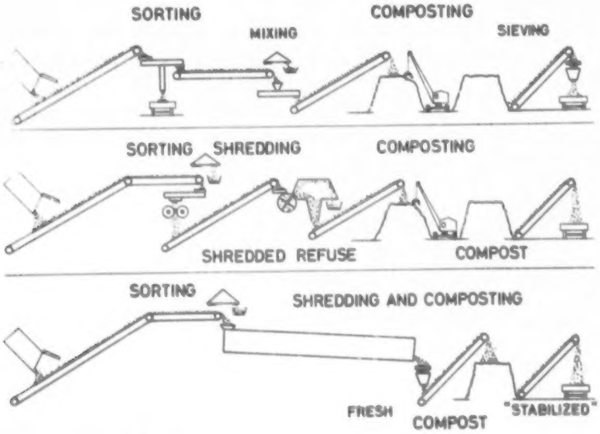
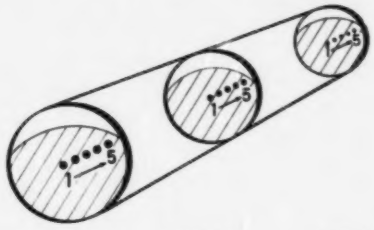


Figure 1. Different refuse treatment methods produce different products.

At Baden-Baden (top drawing) the refuse is processed by rough sorting, mixed with sewage sludge, windrowed for four to six months with one or two turnings, and finally screened. The careful sieving is necessary to make a compost suitable for farming or horticulture. At Heidelberg (middle drawing) the refuse is sorted, shredded and separated ballistically. The first product is shredded or rasped refuse with a high content of easily decomposable organic matter. By windrowing with two to four turnings, which is considered necessary because of the small particle size, the organic content decreases and treatment costs are increased. However, this does not necessarily mean that quality is also improved. Obviously, we need to learn how to utilize the energy released during the decomposition process, perhaps by sheet composting on arable land. At Kreuznach (bottom drawing) the refuse is sorted and then shredded in a rotating drum, while the first stage of composting is proceeding. Sewage sludge can also be added. The product that is discharged from the drum after two to seven days is called fresh compost. The fact that it develops heat if stored in piles or windrows indicates that organic decomposition is continuing. These examples show that a variety of compost products can be produced which have different effects on the soil and on crop production.

What happens in the composting process? The importance of the composition of refuse, moisture content, aeration, heating, and processing time have been demonstrated in numerous investigations. For example, by Gotaas (5), Wiley (19, 21), Sauerlandt (13), who used rotating drums with a capacity of 7 cubic feet, and Schulze who investigated the thermophilic phase of the process. Recent research by Banse (4), who has been continuously investigating for five years at the Kreuznach Dano composting plant and has examined not only the composting process in the windrows, but even the first stage, which occurs in the drum. A short summary of some of his results follow.

1. Oxygen and carbon dioxide content measured in the drum in three sections of the drum at five different radial positions are given in Figure 2. Oxygen content decreased with increasing depth and distance from the inlet. Since oxygen consumption was highest in the last section there is some danger of producing anaerobic conditions, but this tendency is diminished by the rotation of the drum and the rolling of the load.--There is no relationship between the measured values of oxygen and carbon dioxide because fresh air was blown into the drum and the system was not closed.



	INLET		MIDST		OUTLET	
	O_2	CO_2	O_2	CO_2	O_2	CO_2
1	4.1	11.4	3.4	10.0	1.8	14.3
2	4.8	11.0	3.2	12.1	2.2	14.8
3	8.6	7.1	5.2	8.4	2.6	10.4
4	13.3	4.3	6.8	6.6	4.4	10.2
5	17.1	0.8	12.8	3.6	6.2	8.0

Figure 2. Oxygen and carbon dioxide content measured in the drum.

2. Temperature and moisture content in the drum are given in Figure 3. The temperature was found to be essentially influenced by the loading rate; the more the drum was filled, the more heat was prevented from being carried off by the air stream. The moisture content varied between 30 and 45 percent. When the temperatures and the moisture were low, the ammonia smell became intensive. This indicated nitrogen losses, which occurred because of less binding by water and less assimilation by microorganisms.

3. Temperatures in windrows of different height are given in Figure 4. Influenced by the ratio of mass to surface, heat was retained longer in the high windrows than in the low ones. Temperatures remained in the thermophilic range for a long time in windrows with high initial moisture content--about half of their original value. With normal or low moisture content the temperatures fall to 30 - 35% and 20 - 25% respectively. High temperatures caused a noticeable and a rather quick water evaporation. This effect can be used to conserve desirable organic matter if a long storage period is necessary and rainfall is low.

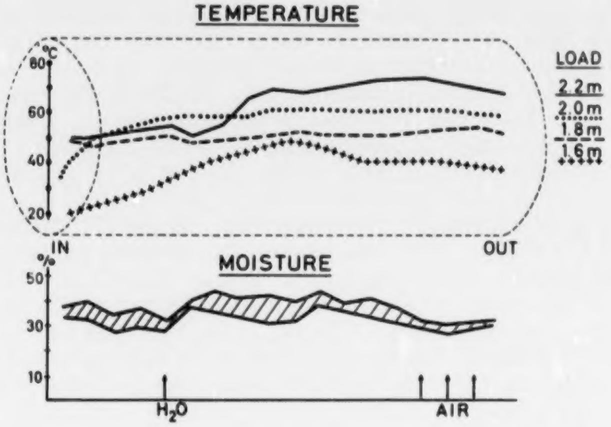


Figure 3. Temperature and moisture content in the drum.

TEMPERATURE °C 30cm BELOW SURFACE

WINDROW HEIGHT m	WEEKS AFTER BEGINNING 1	2	4	8	12
2.2	70	65	63	52	40
1.8	71	63	62	50	37
1.5	69	55	53	46	34
1.0	70	56	54	44	31
0.5	64	48	38	32	22

Figure 4. Temperature of windrows of different height.

4. The organic contents of fresh compost and windrow compost are given in Figure 5. The fresh compost, when discharged from the drum, showed characteristic variations in organic matter content during the course of the year. However, a small, but distinct increase in the monthly values was noticed during the four and a half years of investigation, so that the values of the last two or three years were higher than the average values given in the table. Independent of the values measured in fresh compost, the content of organic matter decreased in the windrows in four months rather similarly, the end values being about one third lower than at the beginning.

ORGANIC MATTER % DRY MATTER BASIS

FRESH COMPOST MONTH. AVER. IN 4-5 Y.

FEB.	APR.	JUN.	AUG.	OCT.	DEC.
17.2	21.2	22.0	25.7	24.0	16.4

COMPOST IN WINDROWS

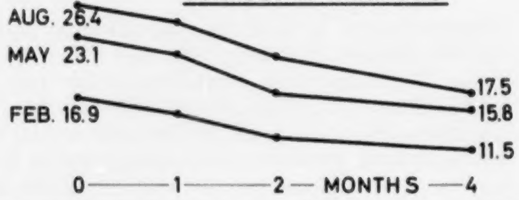


Figure 5. Organic matter content of fresh compost and windrow compost.

5. The structure of windrows is given in Figure 6. To establish aerobic conditions, the material in windrows is loosely stacked in order to facilitate gas exchange. This loose stacking makes it difficult to measure the pore space for a period of time. Gradually, the fabric or structure of the windrow is stabilized by microbial activity, without much change in the windrow height. The graph shows the variations which occurred in the structure of two windrows, six and nine months after the fresh compost was piled. Undisturbed samples of 1000 cubic centimeters were taken with a specially constructed sampling tool. The solids made up 27 percent of the total volume on the average, without important differences between the two windrows, while in the same profile the differences are partially significant. The graph illustrates differences in pore space (an average of about 73 percent, which is large) and variations in the moisture portion (17).

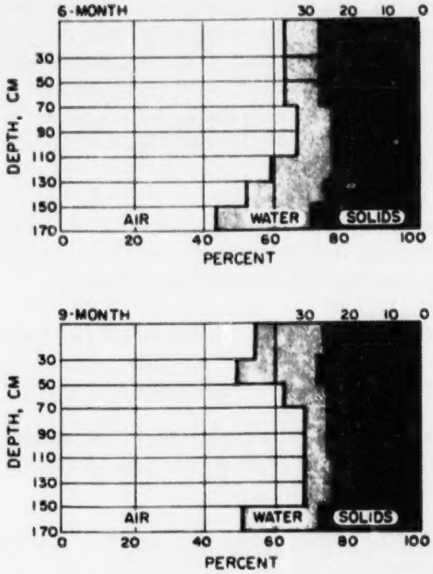


Figure 6. Structure of windrows, showing the distribution of air, moisture, and solids in 1000 cm^3 samples taken out of different depths of two windrows.

6. The carbon dioxide content of a windrow is given in Figure 7. The content of carbon dioxide in the air of a windrow with normal moisture content, 35% in the fresh compost leaving the drum, was measured after one week, one month, and three months, at five depths. After one week, the carbon dioxide content was high, increasing with the distance from the surface, reaching more than 30% at 70 - 90 cm depth. The same tendency was evident later on, however, at a distinctly lower level, without any important differences between one month and three months. The oxygen content (not shown in the graph) was low depending on the rate of decomposition. At a depth of 50 cm below the surface, the oxygen content was less than 5%; at a depth of 10 cm, the values never surpassed 15%.

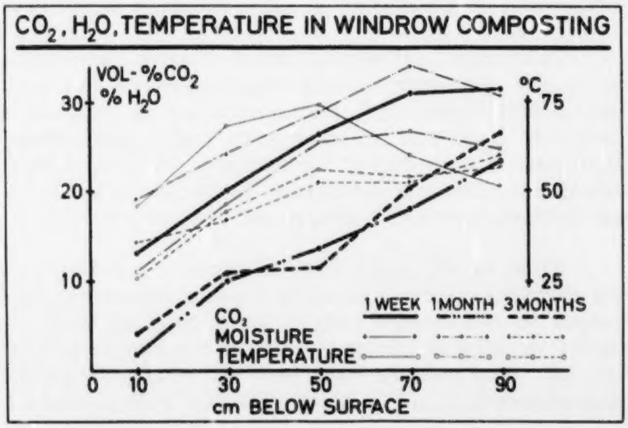


Figure 7. Carbon dioxide content in a windrow.

Although on the basis of the structural analysis, a porosity favorable for the gas exchange could be selected, the air analysis showed that even with high porosity the gas exchange was retarded.

Because of gas and vapor movement in windrows, the measured values for carbon dioxide, oxygen, moisture content, and temperature, are not always characteristic of the process of decomposition at the place of measurement (15).

This short summary of Banse's investigations at Kreuznach has been given as an example of a considerable number of similar investigations that have been undertaken, in order to illustrade the variety of composting processes involved, as well as the conditions prevailing in the different layers of a windrow profile. This variety should be taken as a warning against dogmatic attempts to produce a uniform, so-called "stabilized" compost. The high cost of machinery and installations necessary for the control of aeration, moisture, and heat, and for establishing uniform conditions, i. e., by continuous mixing, can be expected to result in higher total costs. On the other hand, a certain degree of treatment is necessary from the sanitary standpoint to avoid hazards to man, crops, or soil. Since sanitary requirements and regulations will certainly influence the treatment costs, the importance of the investigation conducted by Banse should be apparent.

At Kreuznach, the investigations were essential in the efficient operation of the composting plant. Although it was contrary to the recommendations and experience at other plants, the following policies were developed at Kreuznach:

1. to keep the material in the drum for five to seven days,
2. to secure maximum aeration,
3. to keep the moisture content in the drum just high enough so that no ammonia odor occurs, and low enough so that no hydrogen sulfide or other substanees of offensive odor volatilize,
4. to pile the fresh compost from the drum in windrows as high as possible, 7 - 8 feet,
5. to keep the moisture content in the windrowed material as low as possible,
6. to avoid all turning of the windrows.

The situation at Kreuznach is characterized by the fact that owing to the farsighted initiative of Mr. G. Andres, president of the farm and vineyard owners' union in the district, the composting plant was built and is operated by the landowners themselves to secure the humus husbandry of their soil (2, 16). This means that the plant operates throughout the year, continuously receiving city refuse and producing fresh compost. It is necessary, however, to store the compost in windrows up to three quarters of a year, because there is only a short time after the vintage that it is possible to apply compost to the vineyards.

From the agricultural point of view, the most important question is what effect compost has on soil improvement and crop production. Since plant nutrients are available everywhere in commercial fertilizers, the application of compost as a means of supplying nutrients has become less important for most soils under cultivation. Since compost is a soil conditioner, it is necessary to investigate the reciprocal effect of fertilizer and compost application on the biological and chemical processes occurring in the soil. This also involves soil structure, moisture content, nutrient release, and crop production.

First of all, improved soil structure counteracts soil erosion. To be sure, it must seem like carrying owls to Athens or steel to Pittsburgh, when a foreigner deals with questions of soil erosion in this country where the pioneering work of the Soil Conservation Service in combating soil erosion is known throughout the world. In spite of this fact, it may be allowable to mention that good results have been achieved with refuse compost in decreasing water erosion on steep slopes (3, 9, 11). Many vine and fruit growers in Europe that earn their living on rather small plots in steeply sloping areas, are accustomed to applying stable manure regularly to prevent erosion. This was the case in the neighborhood of Kreuznach, where stable manure has become a rare and rather expensive product, so that the idea of building a city refuse composting plant received the necessary support of the land owners.

Banse showed by field experiments in vineyards near Kreuznach that the field capacity of various soils can be increased lastingly by the application of refuse compost (Figure 8.) The differences shown in Figure 8, caused by a single compost application, are of great importance in this area that has an annual rainfall of less than twenty inches.

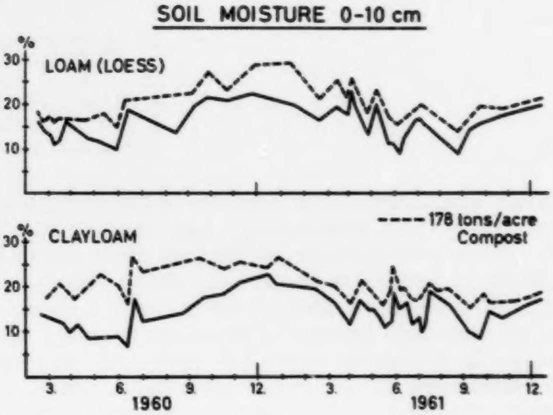


Figure 8. The lasting effect of a compost application on the soil moisture content.

Figure 9 shows the important soil conservation effect on plots arranged for measuring erosion and run-off during a short, but heavy rain. The compost applied to one plot in a great quantity twelve months before the storm almost completely prevented any run-off.

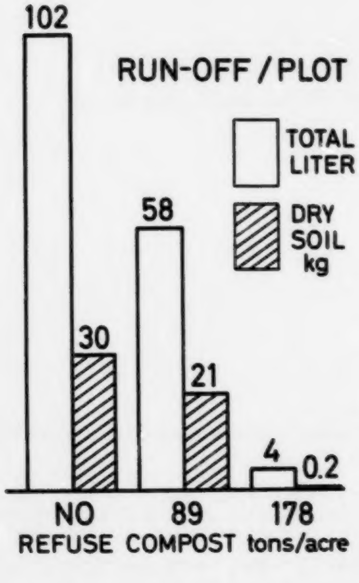


Figure 9. Effect of compost on erosion by rain (slope 30°, size of plot 24 square meters).

The structural stabilizing effect of various organic substances was measured on other plots, as shown in Figure 10. The effect on soil porosity of two applications of organic substances during the preceding two years is shown by the percentage of solids. Treatment with refuse compost or peat gave the same results, although aeration was somewhat better with compost, since peat tends to retain more water than is sometimes desirable.

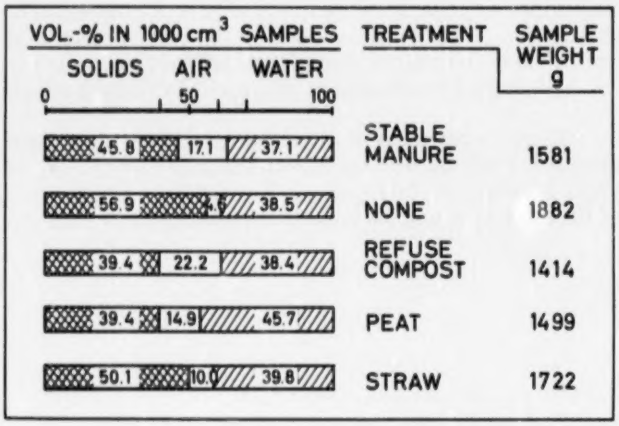


Figure 10. Improvement of soil structure by the application of compost and other organic substances.

Large quantities of compost, up to 178 short tons per acre per year, have been applied in these and other field experiments near Kreuznach. However, it still has not been proved that the desirable effect on soil conservation produced by high rates of compost application are not accompanied by damage to the vines. These experiments must be run for a long time unless plant damage becomes evident. Since these field experiments will be continued, Figure 11 shows only the preliminary results of three years study with annual applications of different organic substances. In this study, sufficient plant nutrients were supplied by adding equal amounts of mineral fertilizers on all plots. Though the differences found are small, the values show that three years of treatment with refuse compost was at least not harmful to the grape production.

YIELD OF GRAPES kg/VINE

SUM 1960-1962

TREATMENT	YIELD
STABLE MANURE	15.04
NONE	14.44
REFUSE COMPOST	15.63
PEAT	14.46
STRAW	13.73

Figure 11. Effect of compost and other annual treatments on the yield of grapes.

Similar positive findings have been obtained in investigations of refuse compost application in fruit-culture and in horticulture (6, 8).

Viticulture, fruit-culture, and horticulture are special branches of land use, with special fertilization and cultivation requirements. They generally do not have sources of organic matter as part of the enterprise. This is different in agriculture -- small grains, corn, potatoes, sugar beets, and others -- where in most cases a supply of organic matter can be found on the farm. Although Kortleven in the Netherlands (10) recommends the application of refuse compost along with other organic materials for improving the humus husbandry of the farm, the farmer's possibilities of supplying his own organic matter cannot be overlooked. For example, stable manure in mixed farms, crop residues utilized by sheet composting, different forms of green manuring, and, highly important, the choice of that program of crop rotation which suits the soil best. However, where a farmer is under economic pressure to produce crops without the possibility of providing for his own humus husbandry, refuse compost can be considered an available resource or perhaps a substitute.

These are our conclusions based on field experiments at Volkenrode with compost products from four composting plants (12, 18). The effects on crop yield that are summarized in the following graphs represent relative values.

The compost produced at Duisburg from refuse and sewage sludge was applied in 1958 and 1960 at three rates and tested on two nitrogen levels. There was little effect on the yield as shown by figure 12, but no significant negative result. However, in 1961, on the plots without nitrogen fertilizer, the after-effect of applying compost at the two highest rates the preceding year is noteworthy.

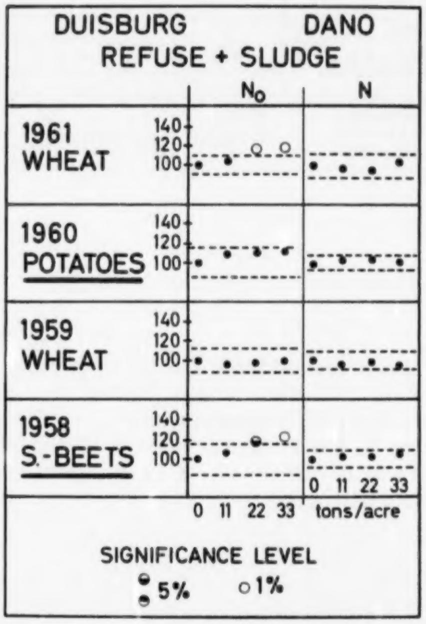


Figure 12. Effect of Duisburg compost applied in three quantities-- 1958 and 1960

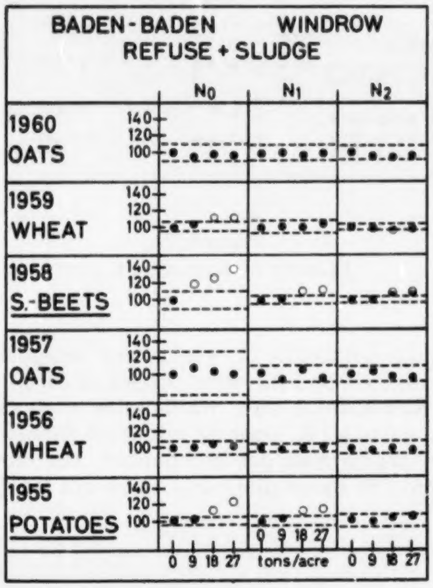


Figure 13. Effect of Baden-Baden compost applied in three quantities--1955 and 1958

The compost produced at Baden-Baden from refuse and sewage sludge was applied at three rates in 1955 and 1958 and was tested on three nitrogen levels. Figure 13 shows that the two highest rates of application increased yields in the two years of application, except in the first year on the highest nitrogen level. Residual effects were noted only in 1959 on the photo plots that were not fertilized with nitrogen.

Fresh compost and windrowed compost produced at Kreuznach, without sludge addition, were applied at equal rates in 1959 and 1962 and tested on three nitrogen levels in two experiments, with and without phosphate fertilization. The yields were a little lower in the experiment without an application of phosphate fertilizers so that the compost effect was more pronounced. The frequent after-effects shown in Figure 14 are worth mentioning. In 1962, the compost products were not applied until several weeks after the potatoes were planted, primarily to test this method of top-dressing, and secondarily to use a fresh compost that was produced after the end of the winter heating period. Yields were less the year of application, distinctly higher, however, the following year. Similar results are shown in Figure 15 for the experiment with phosphate fertilization.

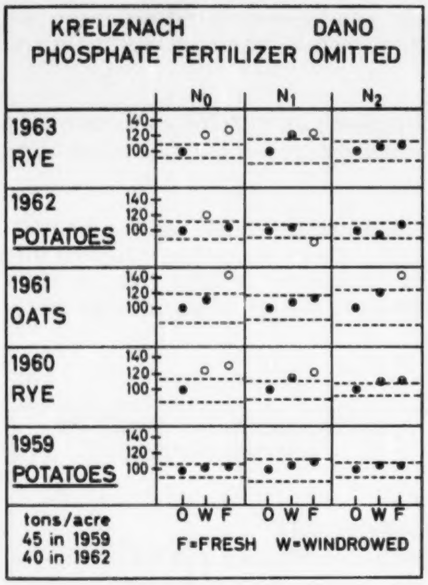


Figure 14.

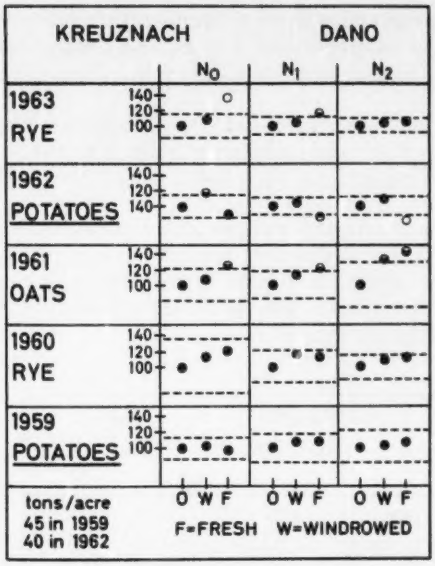
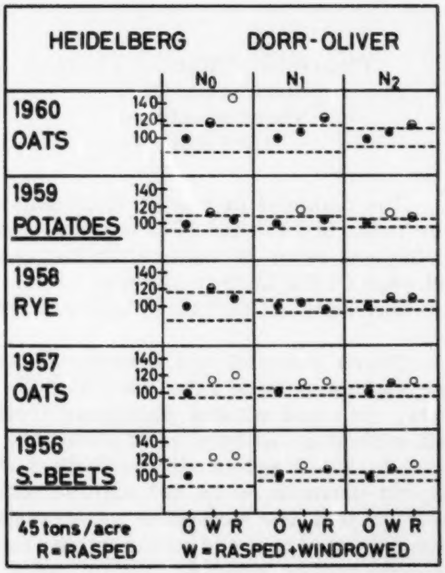


Figure 15.

Effects of Kreuznach compost products applied in 1959 and 1962.

Equal quantities of windrowed compost and rasped refuse from Heidelberg were applied in 1956 and 1959 and likewise tested on three nitrogen fertilization levels. Under the conditions at the experimental site, Heidelberg compost products most frequently increased the yield as shown by Figure 16. Special attention should be called to the residual effects of the shredded material, which was not composted, but only mechanically dressed. This residual effect occurred even on those plots that were not fertilized with nitrogen.

Figure 16: Effect of Heidelberg compost products applied in 1956 and 1959.



Since the products of these four composting plants were not tested in a common experiment on a comparable basis, the results obtained in the single experiments cannot be compared without restriction. In general, the following should be stressed: in 168 compost application tests, 36 percent of the yields were significantly superior to the control, at least on the 5% level, most of them in the year following compost application. This suggests that composting time in windrows or piles should be shortened as much as possible, by transferring the organic decomposition process to plowed land by utilizing a method of sheet composting. We must learn to utilize the energy-releasing process for soil conservation and crop production under a variety of ecological conditions.

GENERAL DISCUSSION

CHAIRMAN MC GAUHEY: Thank you, Dr. Tietjen. You have in a very fine manner, outlined some fruitful areas for research.

QUESTION: How do you determine the uniformity of compost from one year to the next and from one application to the next.

DR. TIETJEN: We were able to determine monthly variations through our investigation, which extended over a five-year period. Because our standards of living are increasing and changing, we have no uniform product from year to year; we have only the product which is produced and that is naturally analyzed according to the nutrient and organic matter contained. It has an organic content of, let us say, 15 to 30 percent.

COMMENT: It is interesting to see that ground rubbish might produce the same results as mature compost when applied to crops.

I would like to comment on the use of sludge in composting. We did some experimental composting on a small scale, and in all cases where we composted sawdust or newsprint (highly organic material), the addition of 20 percent dried sludge (on a dry weight basis) improved the composting considerably, and caused the temperature to go up much faster.

CHAIRMAN MC GAUHEY: This morning it was mentioned that refuse composting is only one phase of the salvaging operation.

QUESTION: What is the yield from the garbage portion? If it is about 20 percent, 80 percent of that is water, we come out with 4 percent compost.

DR. TIETJEN: From the refuse brought into the plant, we get about 60 to 75 percent usable output, depending on the season.

CHAIRMAN MC GAUHEY: It is time now to close this portion of the program.

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Resources for the Future and Industrial Conservation

Philip Gentile, President
General Conversions Systems Corp.
San Fernando, California

I am most grateful for the opportunity to participate in this Conference. I am doubly pleased at this opportunity because I believe that the Conference foreshadows the time--now very near--when the disposal of solid wastes will be one of our major national problems; and the conversion of all waste products into useful new items of commerce will turn our present disposables into one of our greatest future resources.

In view of the background of the participants at this conference I will not dwell on the quantities and widely varied characteristics of solid wastes. Because of the heterogeneous characteristics of this material, we are acutely aware of the disposal problems which solid wastes and rubbish present; and yet, looked at from another point of view, our present solid wastes are largely comprised of materials or items that have served only an immediate purpose and could, therefore, be at least in some other part salvable for return to industry.

Typically, municipal rubbish contains papers, cans, other metals, glass, rags, cardboard, tree clippings, and a wide variety of lesser amounts of miscellaneous materials. Some of these items--if separated economically, one from the other--could be used immediately in a variety of industries and may possibly be converted into the raw materials of an industry yet to be born.

In the past, many salvage and conversion systems have been devised to accomplish what we hopefully call "economic separation" and some of these efforts have actually been put into practice. As an example, in 1944 the City of Detroit launched a salvage and reclamation system based on methods that were known at that time. This system proved to be uneconomical. More recently the Dano Corporation has attempted the adaptation of one of the more popular European solid waste conversion systems to the conversion of municipal wastes. These efforts have materially helped in understanding the problems of composting and bacterial conversion of organic solid wastes.

Viewed over the many years and the results of the many attempts at salvage and conversion, one is led to the conclusion that both the salvage and the conversion features are vitally important to economic disposal of solid wastes. Without first separating the many fractions contained in rubbish, industrial conversion is unbearably complicated by the presence and nature of materials deleterious to the conversion process. At the same time, salvable materials will be lost or so altered as to lose much of their value. Further, conversion of solid wastes into only one or possibly two marketable products critically limits the number of markets which can be reached. Because of the enormous quantities of materials produced from even a modest sized conversion plant, any limited market is soon over-supplied, the results being lower and lower commodity prices.

It is therefore important to carefully combine the elements of "separation" and "salvage" into a complete conversion system--in order to develop a greater variety of by-products and distribute the resultant items and raw materials to the most diversified market possible. This then, has the effect of avoiding the super saturation of any single market.

The above concept points up the fundamental importance of the first step, separation, to which we have directed most of our efforts. The results of our work will be described later in this discussion.

One of the most modern reclamation plants is the one now operating in San Fernando, California. This plant was engineered and built by Lockheed Aircraft Corporation of Burbank, California. Future plants based on the same concept will be offered for sale to municipalities and private companies. These plants will be built by the Westinghouse Electric Corporation, which will warrant their performance.

Salvage of glass, rags, paperboard, etc., is presently accomplished by a combination of hand and magnetic separation. Conversion of the remaining refuse can be accomplished by two alternative methods. One, introduced by Pan American Resources, Inc., is a destructive distillation process, otherwise known as the Lantz Process, in which combustible fractions of solid wastes are converted to combustible gas, charcoal, and a variety of distillates. The several end products resulting from the Lantz conversion process are marketable to many potential users. The combustible gas is useful (1) as a fuel, (2) a reagent similar to "producer" gas for the reduction of ores, or (3) for other chemical reduction processes. In addition, the gas can be "converted" by conventional means to provide electrical energy.

The charcoal is immediately salable in the form of briquettes for barbecue use and shows promise as a soil additive and as the active agent in industrial filtration processes. The oils and tars resulting from this destructive distillation process show promise for use as pesticides, in the preservation of woods and as a source of industrial organic acids.

The conversion of organic solid wastes into compost by means of the Naturizer process is also utilized. This process, after the removal of many salvable items, subjects the remaining material to pulverization and to bacteriological processes which convert it into an organic compost. The daily operation of this plant has proven beyond all reasonable doubt that, with proper salvage and separation techniques followed by additional processing, industrial conversion can be practical and economical. The Key to the conversion of rubbish into resources is the effective separation of the conglomerate wastes into a variety of distinct fractions, followed by the processing, if need be, of the separated fractions into other marketable items.

Because of our experience in the daily operation of this plant, and the evidence of the importance of separation, our company has embarked on an extensive research and development program to explore more fully the separation of solid wastes into useable fractions and useful raw materials.

The first completely automatic separation device developed for use in our plants is the Osborne separator. This device in its present application effects the efficient removal of small particles of glass, metals and other products. It is patented by the Raymond G. Osborne Laboratories of Los Angeles, California, and was designed exclusively for the treatment of solid waste products. A prototype model of the device is now being used to remove the heavy items contained in compost--glass, metals, crockery, sand, and all other materials having a gravity greater than the compost.

The Osborne separator operates as a jig, completely dry and without water, using as a working media a pulsed rising column of air. It is completely automatic and continuous in its operation. Although this particular model was designed specifically for the treatment of compost, the basic principles are applicable to somewhat different models for separation of the fractions in ground raw rubbish. The ability to make these separations between the heavy and light fractions is a formidable step toward the recovery of valuable raw materials from solid waste.

As an example, the small particles of glass recovered by this method have heretofore been unavailable for salvage. Such particles are too small to be removed by hand, yet in compost made from unsorted solid waste, the glass, sand, crockery and metals can amount to approximately 20% of the total weight of the finished product. It is, therefore, not only important to remove this fraction from the compost to improve its salability, but the separated fraction itself, because of its content of metals, glass, etc., is a marketable commodity.

The glass fraction recovered in the separator is useful and marketable as a plastics filler, as an industrial filler, as poultry grit, as a paint extender, and as an additive to paint to add "tooth" to the finish. It is also the basic material from which we have developed a brand new product for industry--a building tile or block of remarkably good strength and architectural beauty. It is made by a protected process using waste glass and feldspar. A local concern is presently being organized to manufacture this tile and place it on the market--thus making it one of the first of many new businesses we hope to see develop around the rubbish reclamation industry.

Our company, under its research contract with Raymond G. Osborne Laboratories, has entered into a series of specific research programs, several of which we believe will soon become successful.

Through the use of separatory devices we are now able to separate un-processed solid wastes into a heavy and a light fraction--the heavy fraction containing glass, sand, crockery, metals, etc.; and the light fraction containing paper, tree clippings, grass, and plastics. In general, the heavy fractions may be described as all materials having a specific gravity greater than one.

I have discussed in some detail several of the programs we are pursuing with the heavy fractions. From the light fraction--the paper and organic materials--we have developed means for making wallboard, acoustical tile, molasses, alcohol, acetic acid, plastics, and even cattle feed. Although all of these plastics show good economic possibility and market acceptance, one of the most interesting is the manufacture of cattle feed. The process we have developed is basically the hydrolysis of cellulose fractions contained in the organic light materials to sugars and edible materials of a carbohydrate nature. Because of several innovations we are also able to improve the protein content to such an extent as to make these materials excellent additives to compounded cattle feed. To date, we have successfully included up to 40% of digested and raw waste papers into a balanced rumin diet, and although this process is not presently in commercial operation, there is good evidence of its economic feasibility.

In summary, the simple and effective separation of light and heavy fractions of solid municipal waste has greatly simplified processing techniques. From this experience we believe that the separatory device previously described and other separatory processes are the key to successful and economic utilization of solid wastes. Presently under study and design are new separatory devices that will eventually make it possible to convert all of our present hand salvage operations to mechanical and automatic separations.

In addition to the glass cullet, cattle feed and other examples previously mentioned, we are investigating the availability of new products and new raw materials. Our future plans are to continue the investigation of new uses for the separable fractions of solid waste materials, and conversion of these separated fractions into the basic raw materials of commerce and new industry.

We are striving by these efforts to do our share in developing a technical and financial movement to convert the nation's solid wastes into solid future resources; to attract to research efforts those men with sufficient vision to see waste as potentially one of our great national assets; and we hope to accomplish at least some of these objectives soon.

GENERAL DISCUSSION

QUESTION: I would like to know what this arrangement costs the City of San Fernando?

MR. GENTILE: The pilot plant was designed and built to prove the system developed in Norman, Oklahoma and to enlarge on the concept developed by the company. It was constructed by private enterprise to use rubbish from the City of San Fernando. I believe that we are charging $1.50 per ton.

QUESTION: What would be a minimum size plant to keep this from being a retail operation?

MR. GENTILE: Our economic studies indicate that we should have a minimum of 150 tons per day, but we advocate 200 plus.

QUESTION: Is that average?

MR. GENTILE: Our refuse comes in non-uniformly. We get 15 percent more during the first half of the week than we get as a weekly average. The plant is geared to run an extra amount the first day. There is enough flexibility within the plant itself.

COMMENT: The list of products is quite impressive and I think this is very good. But what about the marketing of these products on a large scale? If this pilot plant is successful, then there will be a tremendous effort to market this all over the country. Therefore, we could depress the market, especially for charcoal? Can we absorb that much charcoal into the markets?

MR. GENTILE: Of course, we do not advocate putting compost plants in every city immediately, but we do want plants to produce products that the economy and the local market can absorb.

We had several discussions earlier about combining the rural or agricultural wastes along with the residential or municipal wastes. I think that the problem there would be one of transportation. The same thing applies here--transportation is the key to profitable marketing. We are working with the Kingsfort Company on charcoal. They market about 50 percent of the briquettes in this country. In each case we are attempting to work with the leader in the industry that distributes our products.

COMMENT: I am interested in what type of contractural arrangements must be made to provide this service for a certain period of time.

MR. GENTILE: You have touched on a very sore and critical point. We are now offering our plants for sale to municipalities for their use as disposal facilities. We in turn will go in and operate the plants and market the products. If they are profitable, we will share the profits. We have not yet reached the point where we can guarantee performance and make a profit in every case.

QUESTION: Have you run into any researchable problems from the materials handling point of view?

MR. GENTILE: Yes, we have. Separation needs a lot more work. We have approached it in one way, but there are many other ways in which it can be approached and perhaps many easier ways. I think a good part of the research can be directed towards materials handling.

QUESTION: Have you directed any research into the horticulture market or into agriculture?

MR. GENTILE: Only to the extent that it is required to move the products from our pilot plant. We are producing an average of 40 tons a day of material which we are selling primarily for soil erosion control. We have sold several machines for blowing this material along the highways. We are also experimenting with the presoaking of seeds which can be added to the compost and applied in subdivisions.

QUESTION: How much of the San Fernando refuse do you handle in your plant?

MR. GENTILE: We handle all that the city produces and have to supplement it from other routes that we have. The city produces only 40 to 50 tons per day.

CHAIRMAN MC GAUHEY: Thank you, Mr. Gentile. This brings us to the end of our scheduled program for the day and so, on behalf of those who sponsored this conference, as well as myself, I want to thank you all very kindly for your participation.

Summary Plenary Session

Panel Session Summaries

Conference Summary

SUMMARY REPORT - GROUP A

Quantities and Characteristics of Solid Wastes

Casimir Rogus - Chairman

The general subject of "Quantities and Characteristics of Solid Wastes" was treated comprehensively in presentations by Prof. John Bell, Dr. E. Paul Taiganides and Dr. Walter A. Mercer. The papers were concerned with the wastes produced in metropolitan areas, agricultural field and those of industry. It was concluded that more dependable and uniform information, than now extant, must be developed on the quantities, physical and chemical properties of solid wastes:

a. For comparative purposes among individual plants and municipalities on the seasonal and total refuse outputs, costs of their collection and handling, and costs of their disposal by the several methods used.

b. To guide the design and operation of collection and disposal systems.

Designs and operations based on more exact information should effect substantial economies, assure safer and healthier operations, and help develop new ideas and concepts.

Characteristics of Municipal Wastes

The sampling procedures, developed by Prof. John Bell at Purdue University for domestic refuse, should be coordinated with those developed by others for purposes of obtaining uniform acceptable standards. These sampling and analysis procedures should furthermore be expanded to include all of the solid wastes including commercial, municipal and industrial refuse. When such procedures have been standardized, they should be applied to a number of critical American cities, and then maintained periodically for historical purposes and for extrapolation of future values. The individual needs of a given community should be surveyed separately, as required, through the application of these same methods and standards.

Agricultural Solid Wastes

The solid wastes produced by the Agricultural Industry, and to date generally ignored by the Sanitary Engineering profession, were reported by Dr. E. Paul Taiganides of Iowa State University to total more than ten times those conventionally reported for municipal wastes. These agricultural wastes are largely composed of manures produced by the bird, hog, and cattle raising industry, and of crop residues. The manure produced ranges from 0.25 lbs. per animal per day for hens to about 64.0 lbs. per animal per day for cattle. Their disposal by present methods such as spreading, composting, and lagooning, have not been adequately developed, and in most instances are either impractical or too costly. Information on exact quantities and properties, although voluminous, lack dependability.

Industrial Solid Wastes

The waste output of the food canning industry, according to Dr. Walter A. Mercer, approximates 3,000,000 tons annually. These wastes vary in composition and amounts with the types of foods being processed. The problems of disposal are quite similar to those for the Agricultural Industry. Although the National Canners Association have made some efforts to develop better data and methods of disposal, the existing situation requires more extensive research and development.

Recommended Research

Information that is needed to resolve the problem encountered in determining quantities and characteristics of solid wastes must be amplified. It was concluded that the following suggested areas of research are recommended:

1. Extend the development of sampling and analysis techniques to all types of refuse.
2. Perfect a single acceptable standard of sampling and analysis for national and perhaps international application.
3. Obtain uniform data on refuse quantities and characteristics for several critical United States of America cities for historical and comparative purposes.
4. Research the best methods for disposing of agricultural and food canning waste products.
5. The many outsized and special wastes, including demolition and construction refuse, are becoming more troublesome because of their size, amounts, and inadequate existing methods for handling and disposal. Information on quantities, types, and properties is essential to the development of more suitable and economic solutions.

GENERAL DISCUSSION

CHAIRMAN ROHLICH: Thank you very much, Cass, for a very complete, summary.

DR. HEUKELEKIAN: In order to implement some of these recommendations, especially the development of sampling and analysis techniques, I wonder, whether it wouldn't be a good idea to form a committee from this conference, or from the American Public Works Association. This committee would make recommendations as to the standardization of the techniques.

CHAIRMAN ROHLICH: Would this be an opportune time to have either this conference, which has no official standing, or the American Public Works Association, give consideration to the formation of a standard methods committee for solid wastes?

Dr. McKinney, would the conference committee give consideration to this suggestion?

DR. McKINNEY: I think it is an excellent suggestion. If we can't do anything with it, we will see that it is directed to the right people. Something must be done, if we are going to make any real progress in the area referred to by Dr. Heukelekian.

CHAIRMAN ROHLICH: We will ask Dr. McKinney to discuss with his committee members, and if necessary, with the American Public Works Association, the advisability and perhaps the appointment of a standard methods committee on solid waste.

Does anyone see any particular objection to such a procedure? It certainly won't be an easy task.

MR. ROGUS: I would like to suggest, that since this is a matter that concerns the whole nation, there may be better acceptance of the findings by all interested engineering societies, if the responsibility was assumed by the U.S. Public Health Service.

I don't know whether this is within the purview of their type of work, but that is a suggestion.

DR. HEUKELEKIAN: I think the basis of such a committee can be broadened to a national scope, to include other societies such as the American Society of Civil Engineers.

CHAIRMAN ROHLICH: Yes, in much the same way that the Standard Methods Committee on Water, Sewage and Industrial Waste developed.

SUMMARY REPORT - GROUP B

Waste Handling — Storage, Collection and Transportation

William A. Xanten - Chairman

The general subject of "Waste Handling - Storage, Collection and Transportation" included presentations by Dr. Walter Lynn, Mr. F. R. Bowerman, Mr. Philip E. Shayne, Mr. Otto Kuehn and Mr. Harold P. Jensen. Their specific topics concerned, "System Analysis", "Transfer Operation", "Containerization", "Equipment Development", and "Private Collectors".

Systems Analysis

Dr. Lynn's paper constituted a most lucid description of the means by which the "Systems" analysis approach can be applied to the establishment of more efficient refuse collection practices, despite full recognition of the great number of variables inherent in both routing and disposal site locations. Supplemented comments were made by the research team engaged in a project at Northwestern University, from data obtained at Winnetka, Illinois. Typical points raised by Dr. Lynn as research questions included:

1. Should vehicles originate and terminate at same locations?

2. Where should transfer stations be located? (Mr. Xanten subsequently suggested that "when" they should be encorporated into a system would likewise be of some importance).

3. What combination of processing methods should be set up?

4. What improvements can be made in processing?

5. Where should processing stations be located?

Dr. McKinney pointed out some of the obvious difficulties of establishing data from so many of the indeterminable factors and fluctuations not subject to controls.

Dr. McKee expressed the firm opinion that "systems" analysis was an existing tool that should be taught, for its very beneficial affects in emphasizing the overall problems.

Transfer Operations

Mr. Bowerman's slide presentation illustrated three separate and distinct transportation operations in Los Angeles County. It depicted, in part, different methods and equipment, all handling refuse as collected, and in one case, refuse brought to the station by individuals. In addition, Mr. Bowerman included photographs and a discussion of an experimental effort to determine the effects of discharging coarsely shredded refuse into a manhole, over a large sewer, some 15 miles from the treatment plant. Problems were not encountered in the sewer, which had ample flow characteristics, but clogging did occur at the bar screens at the plant.

It was noted that a relatively small proportion, of the total refuse produced, was being handled at transfer stations, and that a new collection unit (one-man operated) of special design and large capacity was proving successful.

The discussion that followed raised the question, as to whether ground refuse, being introduced in large volume to the sewer system, would not add drastically to problems of digestion and sludge disposal at the treatment plant, or whether, utilizing a free and existing conveyor, at substantial distances from the plant, would more than offset the problem thus created. The pros and cons were debated, including a suggestion that pipe lines be laid to convey a refuse slurry directly to landfills.

Baling of refuse and the possibilities of "piggy-back" rail transport of refuse were also briefly discussed.

Containerization

Mr. Shayne's paper included slides of the various types and sizes of containers, with a special presentation by Mr. Langness of the Elgin-Leach Corporation. The recent development, including front, rear, and side loading units, indicated a marked improvement in the adaptability of this method, particularly for housing areas, multi-family dwellings, commercial establishments and industrial plants.

Mr. Shayne indicated a real problem existed in cleaning containers, and that a solution should be found, either by design changes, and/or the use of better grease cutting chemicals.

Dr. Lynn raised the interesting point that loss of compaction at landfills constituted a loss of energy that might be avoided, if the entire load in the vehicle could somehow be discharged as a roll.

Equipment Development

Mr. Kuehn's paper contains a wealth of information regarding technical problems in the field of equipment management and maintenance. He delineates many areas for study and improvement in existing practices. The necessity for getting together with manufacturers, as well as with other large fleet operators in the refuse collection field, was particularly emphasized. It was felt this would engender more respect for the severe service conditions, and strengthen specifications, in both chassis and body design requirements. In a recent purchase of 80 large units, the City of Chicago is requiring the manufacturer to actually undertake a 6-year guarantee maintenance contract, under stipulated conditions. This is an experiment worth watching.

During the discussion, a proposal was advanced for the use of centralized control for 2 or more cranes at incinerators. The use of propane gas units and the relative merits of diesels were also discussed.

Private Collectors

Mr. Jensen outlined the existing pattern of operation by private collection in the Northeastern Illinois Area. Particular reference was made to the difficulties inherent in establishing landfill locations in the area, and the ever-increasing cost of longer hauls.

Waste Handling - Storage, Collection and Transportation

In the Plenary Session, the paper on "Waste Handling - Storage, Collection and Transportation", referred to a number of items having potential research value. One of these items alluded to the desirability of a "quieter" method of refuse collection. This involves receptacles, equipment and personnel. Imaginative research is necessary in this area for in large metropolitan centers of population, traffic problems are becoming acute, particularly during the daylight hours, and refuse collections are usually made, during daylight hours, because of the noise factor. If a system could be achieved, which would permit night-time operations, it is apparent that great gains could be made in efficiency. Receptacle and collection equipment that is acceptable, but noiseless, should be developed. It is noteworthy that most of the effective work, in the physical removal of snow, is accomplished at night, regardless of noise, primarily because of traffic-free conditions.

SUMMARY REPORT - GROUP C

Treatment and Disposal of Solid Wastes

Abraham Michaels - Chairman

The general subject of "Treatment and Disposal of Solid Wastes" included presentations by Mr. L. W. Bremser, Mr. Ralph J. Black , Mr. Charles S. Goode, and Mr. W. A. G. Weststrate. Specific topics concerned "Incineration", "Sanitary Landfill", "Utilization of Sanitary Landfill Sites", and "Composting". This summary does not necessarily summarize the papers but is intended to highlight important parts in the discussions and some of the suggested areas for research.

Incineration

Mr. Bremser's paper dealt with the question of preheating wet refuse, preprocessing refuse, joint ventures involving researchers and municipalities, operation and design as related to stack effluent, controlling refuse characteristics, home incineration, apartment house incinerators, and the possibility of higher operating temperatures of municipal incinerators. During the discussion, the points raised many suggested areas for research and further consideration, such as:

1. The general concensus of opinion was that, since the prime problem in the incineration of refuse is the high combustibility of the refuse, preheating of wet refuse was a minor problem, which might nevertheless be considered as a research problem.

2. Preprocessing of refuse, before it is introduced into the incinerator, including the shredding of refuse and removal of non-combustibles, might be desirable, and could conceivably simplify the incineration process, thereby improving efficiencies and reducing costs. This process should be researched.

3. Considering the experience and the knowledge available in municipal incineration operations, it was determined that the research ventures should, wherever possible, be joint ventures involving the researchers and municipalities.

4. A major problem area in incineration operation and design is the stack effluent. Recognizing that refuse characteristics and public health standards are constantly changing, it is desirable to investigate the contents of stack effluents and determine the effects of changes, if any, on public health factors.

5. The principal of controlling refuse characteristics by regulating the packaging industry was compared to the present situation in the sewage treatment field with respect to detergents. It was determined that this was an area worthy of further exploration.

6. The home incinerator was discussed and mention was made of recent experiences in Philadelphia, in which, tests indicated that a late design, equipped with after-burners, was not as yet acceptable. Considering the advantage of on-site incineration, this method of refuse disposal should be studied.

7. A very important contribution to air pollution, at the present time, is the apartment house incinerator. Although the Incineration Institute of America has studied this problem, it was the consensus of opinion, that this method of disposal is sufficiently important to warrant further study.

8. The possibility of operating municipal incinerators at temperatures considerably higher than those currently used should be considered. It appears that it may be significantly advantageous to burn at temperatures appreciably higher than the 1800 to 2000°F temperatures currently used. Considerable research will be required to accomplish this. However, the possibility of producing more sanitary effluents, at lower costs, warrants research into this concept.

9. The use of "TEPEES" for refuse burners was not considered a desirable method of refuse disposal, despite a report, that it is better than open burning. There is no need to investigate this method any further.

10. There was considerable discussion concerning the purpose of incineration, as a method of refuse disposal, which led to the conclusion, that knowledge about the properties and standards of acceptability of incinerators residue and stack effluents is essential. In order to acquire this knowledge, research pertaining to both of these problems should be inaugurated.

Sanitary Landfill and Utilization of Sanitary Landfill Sites

The papers presented by Mr. Black and Mr. Goode were so closely related it was decided to hear and discuss them simultaneously. Factors arising during the discussion which warranted further consideration and research are:

1. The use of abandoned quarries and excavations is desirable. Since in many instances, these sites contain considerable quantities of ground water, it was concluded that it would be advisable to seal the sites, thereby enabling land filling to take place, without polluting ground waters. A method of particular interest is the use of compacted refuse to provide a seal. Another method, which had been tried elsewhere, was the use of a chemical mixed with earth, thereby providing a blanket, which acted as a seal. The principal of using a seal is worthy of research.

2. It is most desirable to design a landfill operation to meet predetermined end use requirements. In order to ascertain, the landfill operating methods which should be employed, it is first necessary to obtain a basic understanding of the decomposition factors in sanitary landfill operations. A research project designed to relate moisture, pressure, temperature, and other factors to the type of refuse to be used, in the landfill, is necessary. A suggested starting point for this project would be the acquisition of information, about existing sanitary landfills, coupled with tests to be conducted by the researchers at the landfill sites.

3. Since equipment is only one of many factors, it was decided that a complete engineering study by competent professionals was necessary in order to determine proper equipment for any particular sanitary landfill operation.

4. It appears that there is inadequate knowledge pertaining to microbiological considerations of fly emergence from sanitary landfills and that this subject should be studied. In undertaking this study the ecological factors in different parts of the country should be considered.

Composting

Mr. Westrate made a fine presentation which described the various methods of composting used in the Netherlands. The advantages and disadvantages of this controversial method of refuse disposal were discussed. The following studies, particularly as they applied to the United States, were recommended.

1. Determine the types of soils which would benefit by the introduction of refuse compost.

2. Determine the marketability of compost in the United States. Particular emphasis should be placed on its usefulness to the farmer.

3. Examine the various methods of composting currently in popular use throughout the world and determine which of these methods would be most suitable for use in this country.

4. Research the problems involved in the composting of the municipal refuse with raw and digested sewage sludge.

GENERAL DISCUSSION

CHAIRMAN ROHLICH: Thank you for raising some very interesting questions and making some worthwhile suggestions. Are there any additional comments?

There is a study, in progress, at the University of Southern California, in which some information is being gathered. Also, the State of California, I believe, is supporting some research in the Los Angeles area, on gas production and sanitary landfills.

MR. WESTSTRATE: With respect to composting, particular emphasis should be placed on its usefulness to the farmer. It can be an aid and marketable, for gardens and parks, because compost has a better future for private gardens and parks. In the Netherlands, the higher percentage is used for gardens, and by truck gardeners. In addition to this point, there is a question as to the incineration of bulky articles. This is a problem in Europe.

CHAIRMAN ROHLICH: Mr. Weststrate has raised two points. The first deals with the use of compost materials for home gardens and for small truck gardens, such as has been widely used in the Netherlands, and the second is a question concerning further information about the incineration of bulky articles and material.

MR. MICHAELS: The answer to the first is that we agree. We felt that the emphasis should be placed on the use by the farmer, but certainly, knowledge, as to its marketability in other areas, is worth while.

As far as the problem of bulky refuse is concerned, we feel that this is covered to some extent in the pre-processing suggestion, which would recognize, that bulky refuse must also be pre-processed to be incinerated.

PROF. PURDOM: With respect to the recommendation on "TEPEE" burners, I agree with the statement generally; however, it might be well to indicate that there is need for developing short life incinerator-type disposal methods. They would be useful in connection with demolition operations on expressways.

MR. MICHAELS: Are you talking about design or research? I believe there is sufficient knowledge available now to design a short-life incinerator.

CHAIRMAN ROHLICH: In other words, this represents a development step rather than a research step.

MR. MICHAELS: I think so. Will you agree with that?

MR. XANTEN: Yes.

CHAIRMAN ROHLICH: It is a good suggestion.

MR. GILBERTSON: With reference to the landfill area, an elaboration could have been made on a number of things in terms of utilization of this method. Since it is basically a biological decomposition method, it would seem entirely possible to investigate various ways of changing, accelerating, or otherwise improving this approach. You mentioned moisture compaction, but I didn't see anything concerning the use of different biological seeding methods.

CHAIRMAN ROHLICH: Mr. Gilbertson has suggested the possibility of giving consideration to specific biological innoculum or seeding for the fermentation operations that take place in landfill.

MR. GILBERTSON: The same thing could be said about any biological method. This has been investigated in sewage treatment. For example, in the treatment of paper mill wastes, where you have lignites, that are difficult to break down, the possibility exists of finding very specific types of innoculum that will break down these lignites.

SUMMARY REPORT - GROUP D

Processing Conversion and Utilization of Solid Wastes

P. H. McGauhey, Chairman

The general subject of "Processing, Conversion and Utilization of Solid Wastes" included presentations by Mr. William S. Story, Dr. Samuel A. Hart, Dr. Carl Tietjen and Mr. Philip Gentile. The papers discuss the utilization of salvaged materials, the nature of agricultural wastes, utilization of compost and development of by-products by using wastes. The following summarizes the highlights in the presentations, with suggested areas for further study and research.

Salvage Industry

What happens behind the scenes, once salvaged material has left the segregation site, was the theme of Mr. Story's discussion of the "Salvage Industry". Speaking primarily from the viewpoint of the utilization of salvaged metals, he pointed out in his formal paper, and subsequent discussion, that there is a tendency for the steel industry to demand purer and purer scrap, while turning out an increasing volume of sheet, which has a high content of copper, lead, and other non-ferrous metals. This appears in stoves, refrigerators, and the like, which increasingly are being rejected by the salvage industry. Hence, if the scrap market is to hold up, research on copper reduction from sheet metal is an urgent need. The same is true for removal of tin from tin cans. Incineration is inadequate to remove this tin, and cans are, therefore, of limited salvage interest. There are indications that a resurgence in the declining market for scrap will develop within 5 years, particularly, as non-integrated steel producers increase in number, new hearthing methods develop, and research reveals new uses for scrap.

Increasing selectivity for paper, rags, and glass, as well as for metals, is being felt by the salvage industry, and is reflected in a growing cost of segregation and a consequent decline in the attractiveness of salvage, as a disposal method.

In view of the changing nature of salvage needs, there seems to be a discernible decline in the function of the private operator in refuse disposal, and an increase, in public responsibility, for solid wastes management. Rubber tires, automobiles, household appliances, and metal millings are being rejected by salvage operators, who once handled such at a profit.

The exact role of the salvage operator, in the overall picture of solid wastes disposal, is unclear and should be studied in the interests of both the municipality and the salvage industry.

From the standpoint of the municipality, research should also be directed to a determination of the changing nature of solid wastes, and to new useful products into which such wastes might be converted.

Agricultural Wastes Processing

Dr. Hart outlined the nature of agricultural wastes, particularly manure, and livestock wastes, and crop residues, which develop in vast amounts in the high intensity zone of contact between urban and rural areas. He described extensive research, in progress, on specific problems, which have health implications through the production of flies, odors, and dust. Both technological and overall research were recommended by Dr. Hart and members of the Panel Session. In the former category, such projects as the following were envisioned:

1. Digestion of animal manures by activated sludge.
2. Wet burning of manutes and sewage sludge by the Zimmerman Process.
3. Mechanical screening of manures to remove relatively inert matter, which may equal 50 percent of the total.

4. Coking of manure to reduce nitrogen while salvaging potassium and potash for fertilizer.

5. Oxidation of manures in algal ponds.

6. Processing of manures and other organic agricultural wastes to produce high value end products.

Overall research might well be directed to the problems of disposing of agricultural wastes, along with municipal wastes, on an area wide basis, as has already been attempted on a small scale in Huntsville, Alabama, and as advocated by P. H. McGauhey in the Plenary Session of the Conference.

Conservation and Field Testing of Compost

The great contrast between agricultural conditions in California and Germany was noted by Dr. Tietjen, especially as regards to the acceptance of compost as a soil conditioner. If compost is to be widely accepted by American Agriculture, a new tradition must be established. The factors necessary in such a goal include co-operation between the producer, processer, and consumer of compostable wastes in finding methods of utilization, and in the development of convincing proof of the value of compost. He pointed out that composting can yield a variety of products from raw shredded refuse to a stabilized humus, each having different soil conditioning values. Experiments directed to a determining of such values were described by Dr. Tietjen. Research needs derived from the presentation and subsequent discussion included:

1. The effect of compost and of methods of compost application on the whole subject of soil structure, nutrient release, biology and chemistry of the soil, and crop production.

2. The short term and long term effects of various composts on crop yields and plants, when applied at different times of the year in a variety of fashions.

3. The control of pathogens by composting.

4. The use of biological activity of the soil to accomplish sheet composting.

5. The effect of various composts on the uptake of radio iodides by plants.

Resources for the Future and Industrial Conservation

Beginning with the observation, that only a portion of the usefulness of solid materials have been utilized at the time they become "wastes", Mr. Philip Gentile described the highly imaginative approach his company is making to the problem of wastes utilization. To maintain an unsaturated market for converted wastes, he explained, it is necessary to develop a maximum number of by-products. To this end, a very high degree of segregation is imperative, and research should be directed to efficient automated methods of segregation. Thereafter, research should be directed to the development of useful products from the separate fractions, with particular attention to local markets and industries. Several such products already in prospect include charcoal briquettes, plastic filler, wallboard, ornamental tile, and cattle feed.

GENERAL DISCUSSION

CHAIRMAN ROHLICH: Thank you very much, Mr. McGauhey. Would someone like to comment or raise a question?

MR. GERRING: Mr. Chairman. One of the important things, that has come out of this conference, after listening to the summaries, is the inter-disciplinary approach to the problem, primarily from the scientific viewpoints, in the fields of chemistry, biology and physics. In addition to the strictly scientific aspects, we have brought out the importance and the interests of economists, systems analysis, statistics, policy makers, administrators, and the many individuals experienced in operations. This should be remembered. These are the people who make the observations, experience the problems and pitfalls in the collection and disposal of solid wastes, that can lead to research.

One of the primary purposes, of the conference, was to interest young researchers in solid waste research as noted in Dr. McKinney's letters of invitation. I am wondering whether there is some way of evaluating the results of this conference, with respect to the young researchers who have never been involved in the field of solid waste. Obviously, such an evaluation isn't possible over night. On a sample basis, however, it may be possible to determine, from those in attendance if they are interested and what their problems might be.

Mr. McGauhey has noted that the total cost, of the disposal of waste, is approximately $2 billion a year. If five percent of this amount was used for research purposes, it would amount to $100 million a year. Obviously, we will not become so involved in research in the near future, since people must first be trained in the field. Perhaps, Mr. Steed will discuss the potentialities, of the training programs, that have been or are being developed in the Public Health Service, through their Division of General Engineering.

CHAIRMAN ROHLICH: Thank you, Mr. Gerring.

I would like to add that Mr. Gerring omitted the word "engineer", but I assume he did that, since there are mostly engineers present, and he knows they are deeply concerned.

PROF. BLOCK: I would like to make a comment with reference to Mr. Gerring's remarks concerning the interdisciplinary relationship. This has been one of the most valuable conferences, that I have attended, because of the inter-disciplinary instruction and discussion that was available. I am from a university, and I find, that at a university, like most organizations, one tends to remain in his own discipline, do his work, and not get the inter-disciplinary contacts that are needed. This must be stimulated by techniques, not by just good wishes.

We have, with the assistance of a former Dean of Engineering, brought into the field of discussion, people from all branches of engineering, and physicians, who are interested not only in instrumentation, but model making. In addition, people from other disciplines have joined in cooperative ventures from the early stages of research to the development of courses and teaching. Biomedical Engineering is an example of how you can plan cooperative work, that includes many disciplines.

CHAIRMAN ROHLICH: Thank you. Prof. Block has reemphasized the importance of the interdisciplinary approach. By example, the administration at his institution has been so concerned, they have seeded certain departments with those from areas outside of the particular activity, for a interdisciplinary approach to the problem.

PROF. POHLAND: It is very gratifying to come to a conference where some perspective is given to the young researcher. From the standpoint of our own ideas about the conference, I am going to write to Dr. McKinney and tell him what I think about the conference from what I have seen.

With respect to the problems at our own university, I think it would break down to one word, from the standpoint of research, and that is money. If funds are not available for research, funds should be made available to them.

MR. XANTEN: Mr. Chairman, may I make a comment along those lines. In Washington, D. C., discarded automobiles and truck bodies were becoming a serious salvage problem, due, in part, to a lack of market for scrap metal. People are buying automobiles today with the idea, that when they are through with them, they are going to turn them back to the government, since nobody else will take them. A suggestion was made that the introduction of a small tax of about 10 cents on the title of a car would force a study to solve these problems. The amount of money raised by these means would stagger the imagination. I submit, therefore, that when you buy an automobile, why not have a small tax included in the title cost, that would take care of research on the subject?

CHAIRMAN ROHLICH; That is a very interesting suggestion. Are there additional questions or comments?

PROF. MOLOF: I would like to reiterate an idea brought forth in the summary papers. We have two solid waste problems. One is from natural resources, which is difficult to control. The other is from man-made sources and deserves serious consideration. In other words, let's work through the manufacturer to see if we can coordinate a reduction in cost in waste treatment, with the making of the material. This objective should not be omitted from any consideration.

CHAIRMAN ROHLICH: Thank you, Prof. Molof.

I believe it is evident, from these excellent summaries, that we should express our appreciation to the panel session chairmen for a very excellent job.

Metropolitan Problems of Refuse Disposal

John R. Sheaffer
Resources Planning Officer
Northeastern Illinois Metropolitan Area Planning Commission
Chicago, Illinois

In the Northeastern Illinois Metropolitan Area, there are 6,500,000 people living in 3700 square miles; there are a multitude of local governments--249 municipalities, and 1060 local governments in all, each jealous of the other; safeguarding its own rights and privileges, so to speak. There is a complex competition for available land and water in metropolitan areas which gives rise to a problem of safe and economical disposal of refuse.

Four general observations can be made concerning refuse disposal. First, there is obviously an increasing volume of refuse which needs to be disposed of. This is evident when we consider that, over the next twenty years in Northeastern Illinois, the volume of refuse to be disposed of will be at least 240 million cu. yds. - more material than was moved to construct the Panama Canal. This gives you an idea of the engineering task facing a single metropolitan area, and Northeastern Illinois is not the largest one.

Second, suitable sites are becoming more difficult to obtain. As a general rule, it is becoming increasingly difficult to keep existing sites, let alone open new ones.

Third, public pressure is mounting against improperly operated refuse disposal sites. The tolerance level of people in metropolitan areas is decreasing rapidly so that a dump or a landfill operation, that was acceptable in 1950, is not acceptable in 1963. Thus, there is increasing opposition to the opening of any type of disposal facility.

The fourth observation--perhaps the most important one--is the need to narrow the gap between what we know and what we do. There is a critical need to apply available technology to achieve sanitary non-noxious refuse disposal operations.

In the Northeastern Illinois Metropolitan Area, seventy-five percent of all the dump site capacity is found at open dumps. In addition, sixty-five per cent of the dump site capacity is located in geologic environments, that are potentially unfavorable for refuse disposal. (Based on the potential for pollution of ground-water sources) Surprisingly, the threat of ground-water pollution does not seem to cause a great deal of concern.

Although Lake Michigan is the major source of water for Northeastern Illinois, there are 1,600,000 people who get all of their water from the ground. The population, supplied by ground water, is greater than the total population of metropolitan areas like Houston or Baltimore. If the ground water is assigned a value of 20 cents per 1,000 gallons, it has a continuing value of about $100,000 a day, or over $36 million a year. Ground water is a valuable resource that should be protected.

Unfortunately, it appears that inadequate attention has been given to ground-water pollution. The suggested standards on sanitary landfills, recently prepared by the Public Health Service, assigns only 3 of 100 possible points to water pollution. A score of 80 or more points is designated as a sanitary landfill. Thus, a refuse disposal operation, that grossly pollutes the ground water, could be classified as a sanitary landfill. This shortcoming may be explained, in part, by the fact that most of the research on ground water pollution has been undertaken in arid environments, where little water is available to leach or saturate the refuse. There is a need to begin looking into the humid areas, areas of 30-50 inches of precipitation, where soil moisture content is high, and where there are high water tables.

Such environmental conditions present an altogether different type of ground-water pollution problem than is found in the arid areas of our country.

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Ground-water pollution can occur at sanitary landfills or open dumps. I would like to suggest that there is no difference between a sanitary landfill operation and an open dump, from a ground-water pollution viewpoint. As long as the surface of a refuse operation is kept neat, everyone seems to be happy. It appears to be analogous to a person with a mangled hand going to a doctor and being given a glove to cover the wounds. As long as the surface looks nice, don't worry about the conditions underneath.

Refuse disposal is a significant problem in metropolitan areas, one which needs to be researched from three viewpoints: technical, administrative, and legal. Let me explain each of these.

Technical Considerations

From a technical viewpoint, we need at least to improve our understanding in at least four areas. First, what is the nature and mobility of contaminants which might leach from a landfill? This determination should consider not only bacteriological and viral pollution, but also chemical and biochemical pollution. Is refuse so heterogeneous that it is impossible to make a statement concerning this, or if it can be determined at one landfill, do the results have any transfer value to other landfills with different types of refuse and operations? There appears to be an intense search for numbers, and if anyone publishes a new one, it is snatched up and used whether it is applicable or not to a particular set of conditions.

There is a definite need to develop operational criteria for refuse disposal operations that would provide adequate protection to the ground-water reservoir. What advice should be given to a municipality, that wants to open a landfill on a site that has 33 feet of sand and gravel overlying creviced dolomite? Is it safe to put refuse there? Would 25 feet of cover be safe? Would 50 feet of cover be safe? What would be the safety factor? Does the type of material need to be considered? To simply state that 30 feet of material should separate refuse from a dolomite aquifer is meaningless. Thirty feet of clay would not have the same effect as thirty feet of coarse gravel.

Another consideration is the adequacy of engineering designs to protect ground water quality in unfavorable environments. Are the 12 inches of clay generally used to seal an oxidation pond adequate for a refuse disposal site, which is affected by freezing and compaction of materials which might pierce the clay?

Another technical matter to be considered is the adequacy of a region or a metropolitan area to meet the environmental criteria that might be established. Northeastern Illinois is probably the first area in the country to evaluate its physical environment as to whether or not it was potentially unfavorable for refuse disposal. Perhaps many of you have seen our recent report, containing a map that delineates potentially unfavorable geologic environments for refuse disposal. This kind of information is needed in every metropolitan area.

There has been a lack of communication between technical people and public officials concerned with refuse disposal. In the last three years, I have not encountered a public official, who could really distinguish between a sanitary landfill and an open dump. Good communications, I believe, are a technical responsibility. There must be an effort (a successful one) to communicate research findings to the people who make the decisions. In a democracy, these are the elected officials.

Administrative Consideration

In the area of administration, we are confronted with another metropolitan problem: how to fragment an area for the best operation. There are 3700 square miles in Northeastern Illinois, larger than the State of Delaware and approaching the land area of Connecticut. Such an area appears to be too large and should be broken down into operating districts. How should it be divided? This is an administrative research problem. Should it be divided into operating regions which presently exist? In Northern Illinois it was possible to define 22 distinct operating regions. However, disposal sites are opening and closing every month. Such a dynamic situation is extremely difficult to study.

Another administrative problem, that needs to be researched, is the intergovernmental cooperation between numerous municipalities. A slogan can be used to summarize the official position of most municipalities, that is: "Take your dump elsewhere." Dumps are necessary, but take them elsewhere. At a recent public meeting, where a number of municipalities were attempting to cooperate on a refuse disposal facility, the village president of the municipality which was nearest to the proposed site, dramatically stated that it would be located there, only over his dead body. He endorsed a policy of cooperative action, but wanted the site to be located elsewhere.

The problem is further complexed because many municipalities have no edge of town. In the old days, you could go out to the edge of town and locate a dump. But many municipalities are now completely surrounded by other municipalities. There is no edge of town. There is no vacant land. The older municipalities are completely built up. Thus, intergovernmental cooperation is becoming a necessity.

Legal Considerations

An evaluation of legal controls over refuse disposal in a metropolitan area shows two extremes. Some local governments have stringent legal controls that have no basis in fact or technical validity. In other sections, however, you will find the other extreme--no controls. There is a need for some uniformity among local controls, since an adverse operation in one municipality has the potential of affecting neighboring municipalities.

Until the last session of the Legislature in Illinois, (1963) open dumps were legal. It was only a few months ago that legislation was introduced and passed, prohibiting open dumps. No doubt you will find that open dumps are legal in many other states as well.

Research Needs

As a result of the analysis of Northeastern Illinois, it is possible to isolate at least three solid waste disposal research problems.

First, there is a need in humid areas to prepare detailed ground and surface water budgets for sanitary landfill sites. These budgets should include inflow and outflow, as well as data on water quality changes. Ideally, this should be done for different climatic regions. Research in California concluded, that rainfall did not penetrate or leach through a landfill. This might be explained, in part, by the soil moisture deficit; and by the fact that there are only six or seven inches of rain. On the other hand, in areas where the soil is saturated much of the time, and where there are 30, 40, or 50 inches of rain, the same conclusion may not hold true.

A second area for research is the bacteriological and chemical analysis of leachates from refuse disposal sites. In addition to routine laboratory analyses, the samples could be evaluated statistically in relation to variations in the physical environment at the sites. This becomes a very complex research topic because the variables are interrelated. I would suggest that the multivariant statistical technique, which would take the interrelated variables and sort them into independent components and then relate these components to the samples, would be a useful technique for solid waste disposal research.

A third topic of research would be the study of existing disposal sites that are located in the environments potentially unfavorable for refuse disposal. This would enable some assessment of changes which have taken place in the physical environment as a result of the refuse disposal operation. Until we know what changes take place, we cannot set up meaningful standards or criteria to be adhered to, when opening new sites. In other words, standards must be based upon a consideration of natural environmental factors, as well as any changes in the environment, that may take place after fill operations are begun.

These problems are not insurmountable and can be dealt with through adequate research. We should be able to say emphatically what is a safe site for refuse disposal and what is not. By doing so, we will be gaining the public confidence--something that presently is woefully lacking!

GENERAL DISCUSSION

CHAIRMAN ROHLICH: Thank you very much, Mr. Sheaffer. Are there any questions of Mr. Sheaffer?

PROF. RYCKMAN: Can you tell me how many city planning reports involving factors, such as water and sewage considerations, give recognition to refuse problems?

I recently had an opportunity to read some state reports and noticed that all factors were considered, except refuse collection and disposal. I wonder if you can tell me how prevalent is this situation?

MR. SHEAFFER: Your observation is correct. Very few planning agencies have ever given any consideration to refuse disposal.

I believe we produced the first scientific evaluation of refuse disposal in a metropolitan region. The areas, which were potentially favorable for refuse disposal, were mapped on a regional scale. In other words, we mapped the area already built up and the undesirable geologic environments, and then showed, that the remaining areas were potentially favorable for refuse disposal.

As a result of the report, there is more and more interest in this. I would suspect, that in the very near future, you will find planning agencies on local and state levels, giving it more consideration than they have in the past. The planning consultants of a number of municipalities are now coming to us. They are interested in the location of desirable areas and estimates of refuse produced for determination of the future site size.

CHAIRMAN ROHLICH: Mr. Sheaffer, would you tell us from whom we may obtain a copy of this report?

MR. SHEAFFER: The report is "Refuse Disposal Needs and Practices in Northeastern Illinois", and you could write to the Northeastern Illinois Metropolitan Area Planning Commission, 72 West Adams Street, Chicago, Illinois. The zip code is 60603.

CHAIRMAN ROHLICH: Thank you very much.

MR. GILBERTSON: We have been very concerned with a lack of inclusion of solid waste problems in connection with metropolitan planning. Some three or four years ago, this topic was included, as one of the chapters, in our environmental health planning guide. Since that time, it has been included in all of the conferences and training courses on environmental planning, that we have sponsored. We worked closely with Mr. Sheaffer and the Northeastern Illinois Metropolitan Area Planning Commission on this matter. In your discussion, you have largely concentrated on the question of ground water pollution in relation to sanitary landfills and dumps. From your studies of the entire Northeastern Illinois Metropolitan Area, to what extent was it feasible to investigate other aspects of the solid wastes problem in relation to planning? I am thinking, for example, of the relationship of the land use situation generally, transfer stations, traffic problems, and all of the other things generated by solid waste operations in urban areas.

MR. SHEAFFER: We attempted to touch upon all of these problems. On the basis of an economic consideration, there isn't a land use, I know of, that can compete against a sanitary landfill in Northeastern Illinois. I can illustrate this by actual figures.

I know of a refuse disposal operation that is going to be located on 160 acres of land, Based on the going rate, which is charged for the fill, this piece of property will yield an income of over $10 million. The rental, for the land, will be approximately $1 million and operational costs nearly $1 million. You can't have a better investment. After you fill it, you still have your land.

This land is quite expensive. It can compete favorably against industrial land uses. It can compete against any other type of land use. The reason, for this, is the public stigma associated with refuse disposal, and the difficulty of obtaining sites. In other words, there are many sites which would be used in Northern Illinois, except the public won't accept them and as a result, you have created an artificial market condition. You have created a condition where refuse disposal is much more expensive than it should be.

We attempted to focus on many of these sociological problems, but were unable to provide the answers. It is a matter of understanding, psychologically, the reaction of a group. I have seen a municipality, of 2200 people, hold a zoning hearing for approval of a disposal site. There were over 600 people at the hearing to oppose the opening of the site.

DR. KAISER: In what way would incineration help? You need less land area for the final disposal. You didn't mention that in your talks. Would you give us your views?

MR. SHEAFFER: At the present time, we incinerate approximately 35 percent of the refuse in Northern Illinois to reduce the volume. Ultimately, the residue goes to a disposal site, and for that reason, it was excluded. In our analysis, we evaluated the incineration capacities and associated problems, air pollution problem, and even slime feeding. We attempted to evaluate all the methods being used. Most of these other methods reduced the volume, which ultimately has to be disposed of, and that is the way we treated it.

CHAIRMAN ROHLICH: Are there other questions? Mr. Sheaffer, this has been a very stimulating discussion. We thank you for your presentation.

Resources For Research Support

Henry C. Steed, Jr., MPH
Assistant Chief, Research Grants Branch
Division of Environmental Engineering
and Food Protection
Public Health Service
Department of Health, Education, and Welfare
Washington, D. C.

Although the title of this paper is limited to "Resources for Research Support", my presentation will include information as to recent research contributions to the field of Solid Wastes, as well as problems facing the field, both from the research and training standpoints.

The problem of what this country will do with its ever-growing piles of solid wastes is one of the more serious problems facing the urban areas of our nation, and seriously concerning workers in the field of Environmental Health. It has been stated that upwards of $3 billion annually is spent in handling and disposing of these types of wastes. It is apparent that there is an extreme lack of basic information that will help solve some of these problems, which leads us to only one conclusion, and that is the need for more research into the fundamental problems related to Solid Wastes.

In order to develop adequate and efficient control methods, an overall approach, which will utilize both basic and applied research, technical consultation, training standards, as well as development and demonstration, must be activated. Although some research has been done in the Solid Waste field, it is exceedingly small compared to the problems that remain unanswered. For example, in view of the shortage of usable land and demands for cleaner air, how will the communities of this country dispose of their solid wastes in the future in an efficient, safe, and economical manner. What are the most economical means of collecting and storing these wastes? How do we handle the large volume of demolition wastes from urban redevelopment projects in order to prevent unsightly dumping and air pollution problems?

It would be a difficult task to attempt to give here an overview of all the research that has been conducted in the past relating to the problems of solid waste. However, I would like to briefly review some of the more recently conducted studies and some that are presently active in this field. Reports of other research have appeared in a variety of technical journals and in other countries, and many of these articles have been annotated in a series of bibliographies that have been prepared by the staff of the Division of Environmental Engineering and Food Protection of the Public Health Service, and are available upon request (1)*.

Although several agencies, both private and public as well as industry, have supported research in the Solid Waste field, the Public Health Service through its Research Grants Program appears to have supported the bulk of the research in recent years. The Research Grants Branch of the Division of Environmental Engineering and Food Protection in fiscal year 1963 and during the first four months of the current fiscal year has supported 10 projects at a level of approximately $200,000 per year. There are currently 4 projects pending final review totaling more than $175,000 in support.

A brief review of the currently active research being supported by the Division is as follows:

Garbage and Waste for Mushroom Production, by Dr. Seymour S. Block, Associate Research Professor, Department of Chemical Engineering, University of Florida, Gainesville, Florida.

This study now in its fifth year, is aimed at the preparation of composts from municipal and industrial wastes; converting them to useful products such as composts that are capable of yielding mushrooms for human consumption, protein and vitamin rich fungus mycelium for animal feeds, and humus fertilizer for plant growth. Work to date on this project has been quite successful in demonstrating that when properly blended, fortified, and composted, these materials will support mushroom growth and produce in good yield mushrooms for food. The project has also demonstrated the effectiveness of small composting operations.

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* Numbers in parentheses ( ) refer to the appended references.

Bacterial Contamination from Hospital Solid Waste, by Richard G. Bond, Professor, School of Public Health, University of Minnesota, Minneapolis 14, Minnesota.

This project now in its fourth year is a study aimed at assessing hazards involved in solid waste handling and associated housekeeping procedures in a representative cross-section of hospital institutions. Waste handling techniques and resulting bacteriological contaminations are being investigated in production areas, storage and utility areas, and at the location of ultimate disposal. All types of hospital solid waste are included in this investigation.

Sanitary Landfill Investigation, by Jerry C. Burchinal, Associate Professor, Department of Civil Engineering, West Virginia University, Morgantown, West Virginia.

This study is currently in its second year and is basically a bacteriological study of the sanitary landfill. Investigators are attempting to identify groups of micro-organisms which are active in aerobic and anaerobic refuse decomposition, to determine the rate of change in the environment of varied refuse from aerobic to anaerobic conditions, and the effect of moisture, temperature, and adequate nitrogen on this change. Other facts such as gas production will be investigated, as well as the effects of landfill seepage on streams and wells in the vicinity of the landfill.

Sanitary Engineering Applied to Livestock Manure, by Dr. Samuel A. Hart, Associate Professor, Department of Agricultural Engineering, University of California, Davis, California.

This investigation also in its second year, is an attempt to develop sanitary and effective methods of managing the manure produced on concentrated livestock farms such as dairies, beef feed-lots, and poultry farms. Factors under investigation are: the development of methods and machinery to collect the manure at the source, laboratory and pilot plant operations for treatment, processing, and stabilizing the manure, and final techniques for disposal of the by-products.

Factors Controlling Utilization of a Sanitary Landfill Site, by Robert C. Merz, Professor, Civil Engineering, University of Southern California, Los Angeles 7, California.

This study, now finishing its third year has provided helpful information of the effects of physical and chemical phenomena on the rate of decomposition of organic matter in a sanitary landfill. The investigators have conducted their research using practical field tests at a large disposal operation in the vicinity of Los Angeles, California. The tests performed have considered the influence of moisture, soil admixture, depth of field, type of soil, aeration, and temperature. The results to date have been published in the report titled, "Factors Controlling Utilization of a Sanitary Landfill Site (2)".

Mathematical Simulation of Refuse Collection in Disposal Systems, by Dr. Abraham Charnes, Professor of Applied Sciences and Economics, Northwestern University, Evanston, Illinois.

This project now in its second year is aimed at the development of a mathematical model to simulate the refuse collection and disposal problem. The mathematical model will give an optimum solution to the problem based upon considerations of direct cost factors and pollutional levels to be expected from the operation of the disposal processes involved. An example would be the factors such as those that might be expected from air pollution as a result of incineration.

Handling, Treatment and Disposal of Animal Wastes, by Walter A. Mercer, Assistant Director of Laboratories, National Canners Association, Western Research Laboratories, Berkeley 10, California.

This project, in its first year, is aimed at providing urgently needed information as to a rapid, aesthetically acceptable, reliable and economical method of disposal for the high moisture, solid refuse produced in the harvesting and processing of fruits and vegetables. In pilot studies using aeration bins, mixtures of fruit and vegetable canning waste will be composted with dry, moisture-absorbing materials. Experiments will determine the nature of the admixtures suitable for moisture control, as well as the minimum volume of such materials which can be used successfully.

In addition to the projects cited as being supported by the Public Health Service, I would like to cite a brief resume of other work being conducted, supported, or participated in by various agencies and organizations in this country.

The American Public Works Association has been concerned and active in solving problems in the solid waste field for several years. The compilation of nationwide statistics and information on refuse collection and disposal practice is of continuing interest to the Association's Committee on Solid Wastes. In addition, the APWA Research Foundation, with financial support from the Kraft Paper Association, has conducted a series of trials on the use of paper bags for the storage and collection of household refuse. Studies with reference to criteria to be included in the standards for the use of paper bags for household refuse storage and collection is being carried out by the National Sanitation Foundation at Ann Arbor, Michigan.

In the American Public Works Association Special Report titled, "Solid Wastes Research Needs (3)", the APWA Research Foundation has assembled a number of suggested research projects in the Solid Waste field and delineated several needs for work in this field, with particular emphasis on the problems encountered by operational agencies.

The California State Water Pollution Control Board is studying the production and dispersion of organic and mineral pollution of ground water by refuse disposal operations. Concurrently, the University of Southern California is conducting a laboratory study to determine the quantity and quality of gas production from the decomposition of refuse. Both studies are being supported by the California State Water Pollution Control Board.

Studies on the vector control aspects of solid waste handling are being conducted by the Bureau of Vector Control of the California Department of Public Health. Other vector studies, particularly those related to fly emergency have been conducted by several cities and industries throughout the country.

The brief overview of recent research activities only serves to point up the complexities of the problems involved. It also serves to illustrate the small amount of work that is directed at a problem that costs the American people large sums annually. If success in the solution of the complex problems in the field is to be attained, then adequate resources, both intellectual as well as financial, must be brought to bear. In addition, future successes must come about through the cooperative efforts of teams of scientists doing research and development work to help man solve the dilemma, that many of our communities are facing with their solid waste problems.

There have been many discussions at the National Conference on Solid Waste Research centered on the many and varied problems facing us in this field. We have seen presentations that pinpoint the problems and needs for the characterization of solid wastes both from the standpoint of their source as well as their bacteriological, chemical, and physical makeup. We have also heard presentations relating to the extremely critical need for more efficient, economical, and useful methods of solid waste disposal. The critical need for more good Solid Waste Research is extremely evident. To meet this need will require the best knowledge available regarding a clear identification of the problems involved and knowledge as to the efficiency of methods derived. To get this knowledge will require continuing research, and evaluation of the effectiveness of the controls applied and a redirection of our efforts and programs where indicated. We know that the majority of research work in the field of Solid Waste today is of a basic fundamental nature and that more needs to be done. However, I would like to stress that it is becoming quite evident that more emphasis on applied research is needed.

Although there are many agencies both inside and outside the Federal Government conducting research in the Solid Waste field, it appears, that the Public Health Service, through its Research Grants Program, has supported the largest portion of this work. As has been previously stated, we know of work that is or has been conducted by state health departments, private industry, consulting firms, and universities all using their own resources, as well as the resources of State and Federal agencies. In this presentation, I would like to stress the Research Program of the Public Health Service and most specifically the Research Grants Program.

In general, all Environmental Health Research in the Public Health Service is conducted on two levels, intramural and extramural. The intramural program is conducted through the use of resources, both facilities and staff, and is conducted through many different types of laboratories and field stations throughout the country. In 1961, the Research Program in Environmental Health was greatly strengthened with the establishment of Research Grants Branches in the five divisions of Environmental Health. These programs were established for the principal purpose of supporting environmental health studies in universities and colleges, schools of public health, state and local health agencies, and other public and private non-profit institutions. Grants in the areas of the social, biological, physical, engineering, and medical sciences are being supported and encouraged, and are aimed at supplementing knowledge and strengthening the programs in environmental health.

The Division of Environmental Engineering and Food Protection, through its Research Grants Branch, supports research projects in the area of its program responsibilities, which include among others, the fields of Milk and Food Science, the control of Environmental Sanitation on Inter-State Carriers, Shellfish Sanitation, Metropolitan Planning for Environmental Health, Swimming Pool Sanitation, Plumbing, General Community Sanitation, and those multiple problems related to solid wastes handling, collection, and disposal. In fiscal year 1963, the Division supported over 200 projects totaling almost $5,000,000 with a representative although small amount, of the program involving research in the Solid Waste field.

The Research Grants program, of the Division of Environmental Engineering and Food Protection, is conducted in a similar manner to those of the total Public Health Service. Applications are received from investigators and referred to a division for support where the research is within the program responsibility of the division. At the same time the project is referred to an independent group of scientists known as a Study Section for review as to its scientific merit from the standpoint of methodology, aims, and objectives; the competence of the individual investigator or investigators to conduct the research; and from the standpoint of its need in the field of Public Health. The Study Section is selected so that it includes the competences required for review of each project. The findings of the Study Section are reviewed and recommended either for approval, disapproval, or deferral by the National Committee on Environmental Health Research to the Surgeon General of the Public Health Service. Each recommendation for approval is assigned a priority reflecting the relative urgency of the project. Projects are finally funded by the Research Grants Branch concerned, to the extent that funds are available in the budget.

Support of projects in the field of Solid Waste is one of the areas of primary concern of the Division of Environmental Engineering and Food Protection at the present time. The health impact of solid wastes are recognized and the need for more basic and applied information in this field is very apparent. Therefore, within the limits of appropriations for research in the field of Environmental Engineering and Food Protection, The Research Grants Branch is receptive to receiving projects that can contribute more knowledge to this field.

It is important for us to keep in mind that the Public Health Service, in cooperation with industry, local communities, and others, should strive to pool their resources to support research aimed at solving the problems discussed at this conference. I would like to emphasize that support given by the Public Health Service should be aimed at nationally important research, which may be expected to develop fundamental information, and that individual communities must and should devote part of their own resources to solving their local problems.

Another major problem is manpower. Progress, not only in research, but in the operational field, is dependent upon an adequate supply of trained scientific personnel. The growth of scientific knowledge and technology in recent years has indicated to us that it takes more school years now to produce a really usable person, that it ever has before. There are several kinds of training grant programs in the Public Health Service aimed at developing competent personnel in their field, not only operational, but from the research standpoint as well.

The Research Training Grant Program is directed at training people in special areas of need. These grants provide for staff, equipment, travel, materials, curriculum development, and for student support.

Another type of grant that can be used to help solve the problem of scientific communications, is the short-term training grant, which supports seminar-type training for the purpose of disseminating new information, discussing problems, or training people in specific operational areas. These are non-academic grants and vary in duration from three days to four weeks. They provide for tuition and for student per diem, but no travel support is provided. In addition, individual traineeship grants for training both public health and research people are available for support of individuals, in schools of their choice, in critical areas of environmental health.

In closing this paper, I would like to reemphasize that the Division of Environmental Engineering and Food Protection, which has the responsibility for the Solid Waste Program in the Public Health Service, feels that a great deal of work needs to be done in this area. Not only do we need to stress fundamental research problems, but we need a major emphasis placed on applied research. A great number of the problems discussed at this conference are certainly appropriate for research support. We shall be happy to advise you in any way that we can concerning the grants program, and if you would like further information, you may write to the Research Grants Branch, Division of Environmental Engineering and Food Protection, U. S. Public Health Service, Washington, D. C., 20201.

GENERAL DISCUSSION

CHAIRMAN ROHLICH: Thank you very much, Mr. Steed.

Are there any questions?

DR. HEUKELEKIAN: This conference highlighted the importance of solving the solid waste problem, and Mr. Steed discussed the possibility of grants, that are available for this purpose, from the Public Health Service.

I was very unhappy to hear that you don't have a demonstration grant. In addition to research grants projects, it seems to me that there is a definite need, especially in this field, for conducting surveys to determine the present status of the problem, and to conduct field studies which cannot qualify as project research grants. I hope that some time we can convince our Congressmen, that this is a very important area for your activity.

MR. STEED: We also, hope they can be convinced. To my knowledge, such a request has been made for two consecutive years.

DR. HEUKELEKIAN: Such surveys are not necessarily local in interest. They can become a very important national contribution.

MR. STEED: They are very definitely needed.

MR. GERRING: In the Public Health Service and in the Research Grants Program, there are several millions of dollars being expended in the various institutions for training. With the establishment of the five divisions in the program area of the Public Health Service, can you tell us what the thinking is program-wise, in relation to hearings in Congress, and the establishment of training programs in the environmental sciences?

MR. STEED: Are you referring to grant programs or intramural training programs?

MR. GERRING: Extramural.

MR. STEED: Three Divisions of Environmental Health currently have training grants - extramural training grant programs. This was brought about by specific legislation in these areas. Until last year, the Division of Environmental Engineering and Food Protection did not have such authority; but they do at the present time. However, like demonstration grants, we have been unable to get an appropriation for categorical training grants, although they have been requested. At the present time, the Office of Resource Development and the Bureau of State Services does have a budget for extramural training grants, which is being used for support of our categorical grants. It is appropriate and desirable, therefore, to apply for these grants. It is not our own Division money, but is available for our use. Such funds are support for solid waste training grants.

MR. ERICKSON: You have referred to the process of the Subcommission Review, and approval or disapproval of research grants. There is one thing that I would like to see emphasized more, since we have stressed the need for getting the young researcher interested in the solid waste activity. That is the necessity of adequate perseverance and encouragement, in terms of submitting research grant applications, and a recognition that this procedure of review may be a traumatic experience for the first time or two. He should be encouraged to reexamine and reapply, when he is unsuccessful in his first or second attempt. In addition, I would urge the more experienced research personnel to give more attention to such encouragement and assistance to their junior men. These are the young men who are coming into the field and should be advised of the importance of adequate preparation and resubmission of research grant applications.

MR. STEED: I would like to add one point. It is very often nerve-shaking when a proposal is disapproved. This can however, be an education. Any applicant, that is disapproved, may request from our office, the reasons for disapproval. Many people do not do this. We do not normally or routinely give the investigators this information; however, we are glad to furnish it upon request.

References

1 Public Health Service, Refuse Collection and Disposal, An Anotated Bibliography, 1960-61, Public Health Service Publication #91, Supplement E, Washington, D. C., 1963.

2 University of Southern California, Factors Controlling Utilization of a Sanitary Landfill Site, Los Angeles, California, 1963.

3 American Public Works Association, Solid Waste Research Needs, Chicago, Illinois, 1962.

Summary of Conference

Dr. Ross E. McKinney
Chairman, Department of Civil Engineering
University of Kansas
Lawrence, Kansas

As we approach the end of this National Conference on Solid Waste Research, it is only natural that we look back on the activities of the past 2-1/2 days.

We have listened to the experts tell us what we know about solid waste disposal as well as the delineation of areas where we need more information. There is no doubt that considerable research is needed in many areas related to solid waste disposal.

Information is lacking on the delineation of the characteristics of solid wastes. We need to know what type of materials we are dealing with as well as the quantities produced and the rate of waste production. We need to know how to move solid wastes from their source to the point of disposal. We need to know how to process the solid wastes for ultimate disposal. What we need most of all are young, imaginative researchers who can see the challenges presented by solid wastes and who accept the challenges.

Whether we like it or not, our system of Sanitary Engineering education is on trial.

There are challenges in fundamental research for the investigator who wants to probe the basic mechanisms of the various aspects of solid wastes. We need biological and chemical research in composting, in sanitary landfill, in collection and storage, and in new treatment methods which have yet to be devised.

There are challenges in applied research which can satisfy the investigator who wants to find immediate solutions to today's problems.

These challenges encompass the biological and the chemical processes, as well as the sociological and the political relationships. We see the need for systems analysis, instrumentation, and equipment design. The problems of solid wastes are far from being mundane. The sky is the limit if we learn to look up. I learned a long time ago that research is exciting only if you see the excitement yourself, and generate your own excitement.

Can our graduate program for sanitary engineering produce the imaginative engineers needed to solve the space age problems related to solid wastes as well as the other problems of environmental sanitation? I believe that our current system of sanitary engineering education can produce the necessary stimulation to satisfy inquiring minds. Although I believe that our educational system has the potentiality, I do not believe we will reach our full potential in the area of solid wastes unless a drastic change in attitude results.

We need a change in attitude as to the importance of engineers and scientists who are concerned with this aspect of environmental health. The public must recognize that quality engineering cannot be purchased on a minimum bid basis. Government officials must respect the engineers' judgment and furnish the leadership required to accept new ideas. The consulting engineers must meet the responsibility to be professional engineers in the true sense of the words. The university professors must accept the responsibility for providing young engineers who will not accept the current situation with regard to environmental health and who will provide the leadership for the future.

The universities form the foundation for teaching and research. If the foundation is weak, the structure above it will fail. In the past the universities have failed to accept their responsibilities in solid wastes. They have failed to produce the eager young engineers who would not accept second class status or produce second class results. University professors have been too willing to perpetuate status quo, too willing to accept old ideas rather than to think of new ideas, too willing to be diluted by offers of fame and fortune rather than accept the responsibility of true teaching.

We face a real crisis because our university professors have failed. How can we expect to have young engineers who are able to rise above the conventional concepts if the university professors are so busy consulting or doing nothing that they cannot keep up with current practice? It is apparent that action is required if we are to rise to the challenges, of today and tomorrow in environmental health.

It is possible to rationalize why the universities are in the position of failing rather than succeeding without blaming the universities or their professors or anyone for that matter. It matters little as to why we are in the position we are in. It suffices that we recognize our situation and move on to solve our problems.

The hope for solving the problems of solid wastes lies with the young teachers who carry on research in order to satisfy their driving urge for new knowledge. It is recognized that unless positive action is taken to stimulate the young researchers, there is little hope for a positive program of lasting value.

The young researchers formed the nucleus for this National Conference on Solid Waste Research. It is to the young professors that the success or failure for solving the solid waste disposal problems belongs.

Few of you were educated as to solid waste disposal. Many of you will refuse to accept the challenge because you have not had the formal courses required, or you lack the vision to see the challenges in solid wastes.

Education is not and cannot be measured in formal courses, but rather in a philosophy of life. We never stop learning as long as we accept the challenge of the unknown. In research, there are no known solutions to unknown problems. Successful research requires an understanding of the problem, imagination to see around the next corner, and daring to try the unusual even when the experts say it is wrong. Research requires an idea and perserverance to see the idea through, come what may.

It was recognized that the young professors could not solve the solid waste problems without guidance from those individuals faced with the day to day problems of solid wastes. We have gathered at this conference the practioners who have met the challenges presented by solid wastes, and who have been successful in solving the problems they have faced. These practitioners are relatively few in number, and readily admit that they need assistance in solving the ever increasing problems in solid wastes.

We hope that this conference will act as a bonding agent between the young researchers and the practitioners. It is essential that the young researchers maintain direct contact with the practical problems of solid wastes for this is an area of applied research. At the same time, the practitioner must recognize that the young researchers can contribute new solutions to solid waste problems.

I believe that the key to successful solution of solid waste problems lies in successful communications between the researchers and the practitioners. We have seen the results of poor communications between the researchers and the practitioners in the water pollution field. The water pollution practice is still about 50 years behind because the researchers have failed to communicate their ideas to the practitioners, and the practitioners made no effort to learn how to use the ideas developed by the researchers. It is true that there have been papers published in technical journals, but there has been no real communication.

There has been, and still is, a void in leadership in the sanitary engineering field. We are few in number, and the problems are many.

We are faced with the unknown and we must take action. Ours is a field where action has been avoided. I am convinced that our inaction has been a result of fear. We have been afraid of making a mistake. We have been afraid that we will not always be right.

Solid waste problems cannot be solved by the conservative engineering philosophy of yesterday. They can be solved only by dynamic engineering action. The future of the solid wastes area lies in the hands of the young researchers here today. If you fail to accept the challenges, there will be stagnation the same as exists in water pollution. As the young professors in our universities, only you can stimulate the new students of sanitary engineering to rise above the level of previous accomplishments. Only you can become the leaders our field so desperately needs. I have faith in your capabilities. I know you can rise to the heights required. You will not fail because you cannot fail.

The success or the failure of this National Conference on Solid Wastes Research will not be known when this session ends. It will take several years to measure the effectiveness of this Conference. It will not necessarily be measured in terms of number of grant applications, although this criteria will be used. It can only be measured by an attitude which produces new ideas and young engineers who face the challenges.

For those of us who attended this conference, it was a success. As with any conference, this one did not occur spontaneously. There were many months of planning and hard work in preparing for this conference.

We have already recognized the efforts of our speakers who have given us a framework to move away from in our discussions. We have recognized the efforts of the Conference Committee who planned the program. I would like to recognize the extra efforts of Mr. Henry Steed and Mr. Ralph Black of the U. S. Public Health Service. They assisted in smoothing out the little bumps that developed during planning.

To the University of Chicago Center of Continuing Education goes our appreciation for their kind hospitality.

Lastly, I would like to recognize the man who more than anyone else, is responsible for the success of this conference, Mr. James Carlisle. Jim was the man behind the scenes at the American Public Works Association who did all the work. Our heartfelt appreciation goes to Jim. Now that it is over, Jim, it was worth the effort. We all thank you for a job well done.

My thanks to all of you for making this conference a success.

The time has come to officially close this National Conference on Solid Wastes Research. The only thing left for us to do is to go home and get to work.

Program

MONDAY
DECEMBER 2, 1963

9:00 a.m. Registration

10:00 a.m. Plenary Session

Presiding:

Dr. Ross E. McKinney,
Chairman
Department of Civil Engineering
University of Kansas
Lawrence, Kansas

Opening Remarks

Dr. Gerard A. Rohlich,
Chairman, Engineering Study Section of U.S. Public Health Service
Professor of Civil Engieering
University of Wisconsin
Madison, Wisconsin

10:15 a.m. Keynote Address:

"Dimensions of the Solid Wastes Problem"

Dr. Jack E. McKee,
Professor of Environmental Health Engineering
California Institute of Technology
Pasadena, California

A. "Quantities and Characteristics of Solid Wastes"

Casimir A. Rogus,
Director of Engineering,
Department of Sanitation,
City of New York, New York

12:00 m. Luncheon

Presiding:

Robert D. Bugher,
Executive Director
American Public Works Association
Chicago, Illinois

"Public Health Aspects of the Solid Wastes Problem"

Dr. Robert J. Anderson,
Chief
Bureau of State Services
U.S. Public Health Service
Washington, D.C.

1:30 p.m. Plenary Session

Presiding:

Wesley E. Gilbertson,
Chief
Division of Environmental Engrg. and Food Protection
U.S. Public Health Service
Washington, D. C.

B. "Waste Handling—Storage, Collection and Transportation"

William A. Xanten,
Superintendent
Division of Sanitation
Washington, D. C.

C. "Treatment and Disposal of Solid Wastes"

Abraham Michaels,
Deputy Commissioner
Sanitation, Philadelphia, Pennsylvania

3:00 p.m. Coffee Break

3:30 p.m. Plenary Session (Continued)

D. "Processing, Conversion and Utilization of Solid Wastes"

P. H. McGauhey, Director
Sanitary Engineering Research Laboratory
University of California
Richmond, California

4:15 p.m. Session Closes

5:00 p.m. Reception

Sponsored by Sustaining Members of the American Public Works Association

6:00 p.m. Dinner

Presiding: Wesley E. Gilbertson

"The Solid Waste Problem as a Congressman Sees It."

Honorable John Lesinski
Representative from Michigan's 16th District
U.S. House of Representatives
Washington, D.C.

TUESDAY
DECEMBER 3, 1963

9:00 a.m. Concurrent Panel Session

Group A—

Subject:

Quantities and Characteristics of Solid Wastes

Chairman—Casimir A. Rogus

Presentation:

"Characteristics of Municipal Wastes"

Prof. John Bell, Research Assistant
Sanitary Engineering, Purdue University
Lafayette, Indiana

Discussion

Group B—

Subject:

Waste Handling— Storage, Collection and Transportation

Chairman—William A. Xanten

Presentation:

"Systems Analysis"

Dr. Walter Lynn
Dept. of Civil Engineering
Cornell University
Ithaca, New York

Discussion

Group C—

Subject:

Treatment and Disposal of Solid Wastes

Chairman—Abraham Michaels

Presentation:

"Incineration"

L. W. Bremser, Sanitary Engineer
Black and Veatch, Consulting Engineers
Kansas City, Missouri

Discussion

Group D—

Subject:

Processing, Conversion and Utilization of Solid Wastes

Chairman—P.H. McGauhey

Presentation:

"Salvage Industry"

William S. Story
Executive Vice President
Institute of Scrap Iron and Steel
Washington, D.C.

Discussion

10:30 a.m. Coffee Break

10:45 a.m. Concurrent Panel Session

Group A—

Presentation:

"Agricultural Solid Wastes"

Dr. E. Paul Taiganides
Agricultural Engineer
Iowa State University
Ames, Iowa

Discussion

Group B—

Presentation:

"Transfer Operations"

F. R. Bowerman,
Assistant Chief Engineer
Los Angeles County
Sanitation Districts
Los Angeles, California

Discussion

Group C—

Presentation:

"Sanitary Landfill"

Ralph J. Black, Chief
Solid Wastes Engineering
Section
General Engineering
Branch
Division of Environmental
Engineering and Food
Protection
U.S. Public Health Service
Washington, D.C.

Discussion

Group D—

Presentation:

"Agricultural Wastes Processing"

Dr. Samuel A. Hart,
Associate Professor
Department of Agricultural
Engineering
University of California
Davis, California

Discussion

12:00 m. Luncheon

Presiding:

Malcolm C. Hope,
Assistant Chief
Program Planning, Division Environmental
Engineering and Food
Protection
U.S. Public Health Service
Washington, D.C.

"Ecological Considerations, Administration of Solid Waste Collection and Disposal Systems and Research Implications"

Frank M. Stead, Chief
Division of Environmental
Sanitation
Department of Public
Health
State of California
Berkeley, California

1:30 p.m. Concurrent Panel Sessions

Group A—

Presentation:

"Industrial Solid Wastes"

Dr. Walter A. Mercer,
Assistant Director
National Canners Association
Western Research Laboratory
Berkeley, California

Discussion

Group B—

Presentation:

"Containerization"

Philip E. Shayne
Executive Secretary-Treasurer
Detachable Container
Association
Washington, D.C.

Discussion

Group C—

Presentation:

"Utilization of Sanitary Landfill Sites"

Charles S. Goode
Assistant Director of Public
Works
San Diego County
San Diego, California

Discussion

Group D—

Presentation:

"Conservation and Field Testing of Compost"

Dr. Cord Tietjen
Agricultural Research
Institute
Braunschweig-Volkenrode,
Germany

Discussion

2:30 p.m. Group B—

Presentation:

"Equipment Development"

Otto Kuehn
Chief Auto Engineer
Department of Streets and Sanitation
Chicago, Illinois

Discussion

Group C

Presentation:

"Composting"

Ir. W. A. G. Weststrate
Managing Director, V.A.M.
(Refuse Disposal Company)
Amsterdam, The Netherlands

Discussion

Group D

Presentation:

"Resources for the Future and Industrial Conservation"

Philip Gentile, President
General Conversions Systems Corp.
San Fernando, California

Discussion

3:30 p.m. Coffee Break

3:45 p.m. Concurrent Panel Sessions (Continued)

Group A—Adjourns

Group B

Presentation:

"Private Collectors"

Harold P. Jensen, President and Executive Director
Chicago and Suburban Refuse Disposal Assoc.
Chicago, Illinois

Discussion

Group C—Adjourns

Group D—Adjourns

5:00 p.m. Panel Sessions Close

WEDNESDAY
DECEMBER 4, 1963

8:30 a.m. Summary Plenary Session

Presiding: Dr. Gerard A. Rohlich

Group A—Summary Report
Casimir A. Rogus

Group B—Summary Report
William A. Xanten

Group C—Summary Report
Abraham Michaels

Group D—Summary Report
P.H. McGauhey

10:00 a.m. "Metropolitan Problems of Refuse Disposal"

Jack Sheaffer, Resources Planning Officer
Northeastern Illinois Metropolitan Area Planning Commission
Chicago, Illinois

10:30 a.m. Coffee Break

11:00 a.m. "Resources for Research Support"

Henry C. Steed, Jr., Asst. Chief
Research Grants Branch
Division of Environmental Engrg. and Food Protection
U.S. Public Health Service
Washington, D.C.

11:30 a.m. "Conference Summary"

Dr. Ross E. McKinney

12:00 m. Conference Adjourns

Conference Registrants

Franklin Agardy, Asst. Professor
Dept. of Civil Engineering and Applied Mechanics
San Jose State College
San Jose 14, California

James A. Anderegg
Environmental Health Engineer
Metropolitan Washington Council of Governments
1701 Pennsylvania Avenue
Washington, D.C.

Dr. Robert J. Anderson, Asst. Surgeon General
Chief, Bureau of State Service's, Dept. of Health, Education and Welfare
U.S. Public Health Service
Washington 25, D.C.

Robert Anderson
Supt. of Public Works
Village Hall
Winnetka, Illinois

John F. Andrews, Assoc. Professor
Dept. of Civil Engineering
Clemson College
Clemson, South Carolina

Elkanah Babcock
5421 Woodlawn Blvd.
Minneapolis 17, Minnesota

Samuel A. Baker, Refuse Supervisor
Dept. of Public Works
City Hall
Pontiac, Michigan

John M. Bell, Asst. Professor
Sanitary Engineering
Purdue University
Lafayette, Ind.

Ralph J. Black, Chief
Solid Wastes Engineering Unit, General Engineering Branch
Division of Environmental Engineering and Food Protection
U.S. Public Health Service
Washington, D.C.

Seymour Block, Assoc. Professor
College of Engineering
University of Florida
Gainesville, Florida

Richard W. Boubel, Assoc. Professor
Mechanical Engineering
Oregon State University
Corvallis, Oregon

F. R. Bowerman, Asst. Chief Engineer
County Sanitation Districts of Los Angeles County
2020 Beverly Blvd.
Los Angeles 57, California

L. W. Bremser
Black and Veatch, Consulting Engineers
1500 Meadow Lake Parkway,
P.O. Box 8405
Kansas City, Missouri 64114

J. Raymond Brisson
President, LoDal Inc.
P.O. Box 6
Norway, Michigan

Robert D. Bugher, Executive Director
American Public Works Association
1313 East 60th St.
Chicago, Illinois 60637

J. C. Burchinal, Professor
Dept. of Civil Engineering
West Virginia University
Morgantown, West Virginia

Tracy C. Calame
Sales Engineer, Illinois Stoker Co.
102 West 7th Street
Alton, Ill.

James N. Carlisle, Asst. Director
Technical Services
American Public Works Association
1313 E. 60th St.
Chicago, Illinois 60637

A. Charnes, Research Professor
Applied Mathematics and Economics
Northwestern University
Evanston, Ill.

S. M. Clarke
Greeley and Hansen, Consulting Engineers
14 E. Jackson Blvd.
Chicago 4, Illinois

John L. Cleasby, Assoc. Professor
Civil Engineering
Iowa State University
Ames, Iowa

Charles Cooke
Information Specialist
Bureau of State Services
Room 2014, South HEW Bldg.
Washington 25, D. C. 20201

Larry Crane
Asst. Sanitary Engineer
Solid Wastes Engineering Section
Special Engineering Services Branch
Division of Environmental Engineering and Food Protection
U. S. Public Health Service
Washington 25, D.C. 20201

R. Bruce Curry, Assoc. Professor
Ohio Agricultural Experiment Station
Wooster, Ohio 44691

William Davis, Head
Sanitary Engineering Division
Texas A & M University
College Station, Texas

F. H. Doe Jr., Sanitary Engineer
Sewer and Sanitation Division,
Arlington County Court House
Arlington 1, Virginia

Harvey J. Dominick
Entomologist, State Dept. of Health
2073 South 4th St.
Springfield, Illinois

James Norman Dornbush, Professor
Dept. of Civil Engineering
South Dakota State College
College Station
Brookings, South Dakota 57007

Donald C. Egbert
General Manager, Southeastern Oakland County Incinerator Authority
P. O. Box 1248
Berkley, Michigan

Richard W. Eldredge
Senior Sanitary Engineer
Environmental Engineering and Food Protection
U. S. Public Health Service, Room 712
433 W. Van Buren
Chicago, Illinois 60607

Dr. R. S. Engelbrecht
Dept. of Civil Engineering
University of Illinois
Urbana, Illinois

Frederick Erickson
Assoc. Regional Health Director for Environmental Services
U. S. Public Health Service
560 Westport Rd.
Kansas City, Missouri 64111

Charles E. Farley Chief
Baltimore County Dept. of Sanitation
Balitmore County Office Building
Towson, Maryland

A. E. Ferguson
Ferguson, Brooks & Kelly, Consulting Engineers
2641 East Buckeye Rd.
Phoenix 34, Arizona

Dr. Donald L. Feuerstein, Asst. Director
Sanitary Engineering Research Laboratory, Richmond Field Station
1301 South 46th St.
Richmond, California

Jerome D. Franklin
Director of Public Service
301 Market St.
Grand Rapids, Mich.

Anthony F. Gaudy, Jr., Assoc. Professor
Civil Engineering
Oklahoma State University
Stillwater, Oklahoma

Emil J. Genetelli
Dept of Civil Engineering
Rutgers University
New Brunswick, New Jersey

P. John Gentile
General Conversions Systems Corp.
Suite 530 - Sherman Terrace Bldg.
18040 Sherman Way
San Fernando, California

Irving Gerring, Executive Secretary
Division of Research Grants
National Inst. of Health
Bethesda, Maryland

Wesley E. Gilbertson, Chief
Division of Environmental Engineering
and Food Protection
Dept. of Health, Education and Welfare
U. S. Public Health Service
Washington 25, D. C.

Tom Gingles, Professor
Sanitary Engineering
University of Mississippi
University, Mississippi

Eugene A. Glysson, Assoc. Professor
Dept. of Civil Engineering
University of Michigan
Ann Arbor, Michigan 48104

Charles S. Goode, Asst. Director
Dept. of Public Works, San Diego County
5555 Overland Ave.
San Diego, California 92123

Dr. H. B. Gotaas, Professor and Dean
The Technological Institute
Northwestern University
Evanston, Illinois

Dr. Sotirios G. Grigoropoulos, Professor
Civil Engineering
University of Missouri School of Mines
and Metallurgy
Rolla, Missouri

Dr. Herbert E. Hall
Microbiologist, U. S. Public Health
Service
Taff Sanitary Engineering Center
Cincinnati, Ohio

Robert K. Hampton
Beaumont Birch Company
61 Hilton Avenue
Garden City, New York

N. Bruce Hanes, Asst. Professor
College of Engineering
Tufts University
Medford 55, Massachusetts

Paul D. Haney
Black and Veatch, Consulting Engineers
P. O. Box 8405
Kansas City 4, Missouri

Roy W. Hann, Jr., Asst. Professor
Radiation Protection Institute
University of South Carolina
Columbia, South Carolina

E. Steane Hare, Asst. City Engineer
Engineering Dept.
453 West 12th Ave.
Vancouver 10, British Columbia, Canada

William M. Harrington Jr.
Asst. Project Engineer
Whitman, Requardt and Assoc.
4th Floor, Loyola Bldg.
2 West Preston St.
Baltimore, Maryland

Dr. Samuel Hart
Department of Agricultural Engineering
University of California
Davis, California 95616

W. A. Herpich
Vice President, Engineering
Hercules Galion Products, Inc.
605 S. Market St.
Galion, Ohio

Dr. H. Heukelekian, Chairman
Dept. of Sanitation
Rutgers University
New Brunswick, New Jersey

Malcolm C. Hope, Asst. Chief
Division of Environmental Engineering
and Food Protection
Dept. of Health, Education and Welfare
U. S. Public Health Service
Washington 25, D. C.

R. S. Howe, Professor
Dept. of Civil Engineering
Southern Illinois University
Carbondale, Illinois

Norman Hume
Director, Bureau of Sanitation
748 City Hall
Los Angeles 12, California

J. E. Jack
Director of Sales
Hercules Galion Products, Inc.
605 S. Market St.
Galion, Ohio

Eugene R. Jarecki
Sales Engineer, M. H. Detrick Co.
2780 Wildwood Lane
Deerfield, Illinois

Ernest M. Jennelle, Assoc. Professor
Dept. of Civil Engineering
Virginia Polytechnical Inst.
Blacksburg, Virginia

Harold P. Jensen, President and Executive
Director
Chicago and Suburban Refuse Disposal
Assoc.
330 S. Wells St.
Chicago 6, Illinois

John S. Jeris, Asst. Professor
Civil Engineering Dept.
Manhattan College
New York City 71, New York

Norman B. Jones, Asst. Professor
Civil and Irrigation Engineering Dept.
Utah State University
Logan, Utah 84321

Elmer R. Kaiser
Senior Research Scientist
New York University
University Heights, Bronx 53, New York

Norman Kenney
Chief, Div. of Research and Standards
Bureau of Engineering
Baltimore County Office Bldg.
Towson 1, Maryland

Frederick Kent
Regional Program Director
U. S. Public Health Service
447 Federal Office Building
San Francisco, California 94102

Ray Kirvin
Research Director, Kraft Paper Assoc.
122 East 42nd St.
New York 17, New York

Edwin H. Klehr
Faculty, University of Oklahoma
306 Chautaqua
Norman, Oklahoma

Kenneth O. Kortanek
Student, Northwestern University
8115 Keystone
Skokie, Illinois

John F. Kraus
Chairman, Intermunicipal Group for Refuse Disposal
4 Edgewood Ct.
North Plainfield, New Jersey

Peter A. Krenkel, Assoc. Professor
Sanitary and Water Resources Engineering
Vanderbilt University
Nashville 5, Tennessee

Otto Kuehn
Chief Auto Engineer
Dept. of Streets & Sanitation
306 W. 37th St.
Chicago 9, Illinois

Irwin Jay Kugelman, Asst. Professor
Civil Engineering
New York University
University Heights, Bronx, 53, New York

George J. Kupchik
Director, Environmental Health
American Public Health Assoc.
1790 Broadway
New York 19, New York

James C. Lamb, III, Assoc. Professor
Sanitary Engineering
University of North Carolina
Chapel Hill, North Carolina

L. J. Langeness
Asst. Sales Manager, Elgin Leach Corp.
222 W. Adams St.
Chicago 6, Illinois

Hon. John Lesinski
Congressman, 16th District
State of Michigan, U. S. House of Representatives
Washington, D. C.

John Everett Lobb
Sanitary Engineer, Division of Sanitation
State Dept. of Health
Bismarck, North Dakota

Raymond C. Loehr, Assoc. Professor
Civil Engineering, Environmental Health Research Laboratory, Nuclear Reactor Center
University of Kansas
Lawrence, Kansas

David C. Ludington, Professor
Dept. of Agricultural Engineering
Riley-Robb Hall
Cornell University
Ithaca, New York

Dr. Walter R. Lynn, Assoc. Professor
Sanitary Engineering
Cornell University
Ithaca, New York

Joseph Malina Jr., Asst. Professor
Environmental Health Engineering, Engineering Laboratories Bldg. 305
University of Texas
Austin 12, Texas

Richard C. Martin
Western Sales Manager
International Paper Co.
Garbax Disposal System
4548 Loma Vista Ave.
Los Angeles 58, California

Frank Massaro
Supt. of Streets, Dept. of Public Works
City Hall, Room 22D
Niagara Falls, New York

Joseph H. McCarthy
Sanitary Engineer, Bureau of Sanitation
404 Municipal Bldg.
Baltimore 2, Maryland

James McEleney
Marketing Research Analyst, International Paper Co.
220 East 42nd St.
New York 17, New York

P. H. McGauhey, Director
Sanitary Engineering Research Laboratory
University of California
Richmond Field Station
1301 S. 46th St.
Richmond, California

Dr. Jack E. McKee, Professor
Environmental Health Engineering
California Institute of Technology
Pasadena, California

Dr. Ross E. McKinney, Chairman
Dept. of Civil Engineering, 217 Nuclear Reactor Center
University of Kansas
Lawrence, Kansas

Dr. Walter A. Mercer, Asst. Director
National Canners Association
1950 Sixth St.
Berkeley 10, California

Abraham Michaels, Deputy Commissioner
Dept. of Streets
904 City Hall Annex
Philadelphia 7, Pennsylvania

Dr. Byron F. Miller
Dept. of Poultry Science, College of Agriculture
Colorado State University
Fort Collins, Colorado

Alan H. Molof, Assoc. Professor
Civil Engineering
New York University
University Heights, Bronx, 53, New York

S. M. Morrison, Professor
Dept. of Pathology and Microbiology
Colorado State University
Fort Collins, Colorado

H. Nugent Myrick, Sc. D.,
Research Fellow
Harvard University
Pierce Hall
Cambridge 38, Massachusetts

Arthur H. Neill
Chief, Special Engineering Service Branch
Division of Environmental Engineering and Food Protection
U. S. Public Health Service
Washington 25, D. C. 20201

M. A. Noel
Chief Engineer, Dept. of Streets and Sanitation
Room 308, 320 N. Clark St.
Chicago 2, Illinois

Robert E. Novick
Regional Program Director
Environmental Engineering and Food Protection
U. S. Public Health Service, Room 712
433 W. Van Buren St.
Chicago, Illinois 60607

Davis D. Odell
Superintendent, Sanitary Dept.
City Hall
Orlando, Florida

Charles R. O'Melia, Asst. Professor
School of Civil Engineering
Georgia Institute of Technology
Atlanta 13, Georgia

John T. Pfeffer, Asst. Professor
Civil Engineering, Nuclear Reactor Center
University of Kansas
Lawrence, Kansas

Wesley O. Pipes, Assoc. Professor
Civil Engineering, The Technological Institute
Northwestern University
Evanston, Illinois

Frederick G. Pohland, Asst. Professor
School of Civil Engineering
Georgia Inst. of Technology
Atlanta 13, Georgia

Earl J. Porter
Division of Environmental Engineering, and Food Protection Consultant
U. S. Public Health Service
560 Westport Rd.
Kansas City, Missouri 64111

Donald E. Proctor, Assoc. Sanitary Engineer
Washington State University
Pullman, Washington 99163

P. W. Purdom, Assoc. Professor
Civil Engineering and Mechanics, Drexel Institute of Technology
319 East Durham
Philadelphia 4, Pennsylvania

Dr. Arliss D. Ray
Dept. of Sanitary Engineering
University of Missouri
Columbia, Missouri

George W. Reid, Professor
Dept. of Civil Engineering
University of Oklahoma
Norman, Oklahoma

Matthew Riddell
Greeley and Hansen, Consulting Engineers
14 East Jackson Blvd.
Chicago 4, Illinois

Lloyd R. Robinson, Jr., Asst. Professor
Dept. of Civil Engineering
New Mexico State University
Box 758
University Park, New Mexico

John W. Rockey, Asst. Chief
Livestock Engineering and Farm Structures Research Branch
U. S. Dept. of Agriculture
Beltsville, Maryland 20705

Edward Rodie
Managing Editor, Public Works Magazine
200 S. Broad St.
Ridgewood, New Jersery

Archie B. Roebuck
Sales Manager, International Paper Company
Garbax Disposal System
220 E. 42nd St.
New York 17, New York

Casimir Rogus, Director of Engineering
Dept. of Sanitation
125 Worth St.
New York 13, New York

Dr. G. A. Rohlich, Assoc. Dean
Professor of Civil Engineering
University of Wisconsin
318 Von Vleck Hall
Madison 6, Wisconsin

Howard B. Ronan
Health Information and Education
Division of Environmental Engineering and Food Protection
U. S. Public Health Service
Room 1217, Tempo R. Bldg.
Washington D. C., 20201

Marcus Rosenblum
Editor, Public Health Reports
U. S. Public Health Service
Room 4527, North HEW Bldg.
Washington, D. C., 20201

D. W. Ryckman, Professor
Environmental and Sanitary Engineering
Washington University
St. Louis 30, Missouri

W. D. Savadge
Division Manager, Union Bag - Camp Paper Co.
382 Cherokee Rd.
Lake Forest, Illinois

John R. Sheaffer, Resources Planning Officer
Northeastern Illinois Metropolitan Area Planning Commission
72 W. Adams St.
Chicago 3, Illinois

George J. Schroepfer, Professor
Sanitary Engineering
University of Minnesota
Minneapolis, Minnesota

Norman Sedlander, Assoc. Professor
Dept. of Civil Engineering
University of Toledo
Toledo 6, Ohio

Philip E. Shayne, Executive Secretary-Treasurer
Detachable Container Association
1601 "W" St. NE
Washington, D. C. 20018

Richard A. Shields
Sales Manager, Converto Mfg. Co.
23 E. Main Street
Cambridge City, Indiana

Rolfe T. Skrinde, Assoc. Professor
Environmental and Sanitary Engineering
Washington University
St. Louis 30, Missouri

Edward Smith
Dept. of Public Works
2955 Weston Ave.
Niagara Falls, New York

Paul H. Smith, Asst. Professor
College of Agriculture
Dept. of Bacteriology, 169 McCarty Hall
University of Florida
Gainesville, Florida

R. E. Speece, Asst. Professor
Sanitary Engineering
University of Illinois
Urbana, Illinois

Elroy F. Spitzer
Engineering Editor, American City Magazine
757 Third Avenue
New York 17, New York

Otis J. Sproul, Assoc. Professor
Dept. of Civil Engineering, Boardman Hall
University of Maine
Orono, Maine

Frank M. Stead, Chief
Division of Environmental Sanitation
State Dept. of Public Health
Berkeley, California

Henry C. Steed, Jr., Asst. Chief
Research Grants Branch
Division of Environmental Engineering and Food Protection
U. S. Public Health Service
Washington 25, D. C.

William S. Story, Executive Vice President
Institute of Scrap Iron and Steel, Inc.
1729 H Street, N.W.
Washington 6, D. C.

Dr. E. Paul Taiganides
Agricultural Engineer
Iowa State University
Ames, Iowa

E. H. Taylor
Market Division Manager, Trade Assoc.
60 E. 42nd St.
New York 17, New York

Dr. Cord Tietjen
Institut fur Humuswirtschaft
Forschungsanstalt fur Landwirtschaft
3301 Braunschweig - Volkenrode
Bundesalle 50, West Germany

George Tomsho
Asst. Director, Public Affairs
American Public Works Assoc.
1313 East 60th
Chicago, Illinois 60637

Norman E. Tucker
Chief, Metropolitan Planning Training Program
U. S. Public Health Service
Taft Sanitary Engineering Center
Cincinnati, Ohio

John Vanderveld Jr.
Executive Vice President, National Disposal Contractors
1913 Martingale Rd.
Wheaton, Illinois

Ralph J. Van Derwerker
Regional Program Director
U. S. Public Health Service
42 Broadway
New York 4, New York

David J. Vargas
Staff Engineer
American Public Works Assoc.
1313 East 60th St.
Chicago, Illinois 60637

John Verhoeks
1064 White Ave., NW.
Grand Rapids, Mich.

John C. Ward, Asst. Professor
Dept. of Civil Engineering
University of Arkansas
Fayetteville, Arkansas

T. A. Ward
Construction Engineer
Caterpillar Tractor Co.
Peoria 8, Illinois

L. C. Wasson
Research Scientist
A. O. Smith Corp.
Milwaukee 1, Wisconsin

Col. Stanley J. Weidenkopf
Preventive Medicine Division
Office of the Surgeon General
Main Navy Building-Room 2530
Washington, D. C. 20201

Ir. W. A. G. Weststrate
Stadionkade 70
Amsterdam, Znid
Netherlands

Max Wilcomb, Professor
Sanitary Science
University of Oklahoma
Norman, Oklahoma

John Wiley
Solid Wastes Engineering Consultant
U. S. Public Health Service
447 Federal Office Building
San Francisco 2, California 94102

Ray E. Williamson
Supervisor, Applications and Markets
Allis-Chalmers Mfg. Co.
P. O. Box 512
Milwaukee 1, Wisconsin

Charles V. Wright
Regional Program Director
U. S. Public Health Service
560 Westport Rd.
Kansas City, Missouri 64111

Eugene B. Wright Jr.
Chemical Engineer
Fertilizer Distribution Branch
Tennessee Valley Authority
Wilson Dam, Alabama

Purd B. Wright III
Midwest Sales Manager
International Paper Co.
Garbax Disposal System
401 Kindelberger Rd.
Kansas City 15, Kansas

Stuart Wright
Division of Environmental Engineering
and Food Protection
U. S. Public Health Service
Washington 25, D. C. 20201

William A. Xanten
3355 Military Rd., N.W.
Washington, D. C.